



# 2016 Minerals Yearbook

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## NIOBIUM [ADVANCE RELEASE]

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# NIObIUM

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Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant.

In 2016, U.S. niobium apparent consumption (measured in contained niobium) was 6,710 metric tons (t), 5% less than in 2015 (table 1). No domestic mine production of niobium ore was reported. Niobium content of world mine production was 64,100 t in 2016, a slight increase compared with that of the previous year (tables 1, 4). In 2016, the United States exported 1,480 t of niobium contained in niobium-bearing alloys, ores, and concentrates (3% more than that of 2015). In the same period, the United States imported 8,230 t of niobium contained in niobium-bearing metal, alloys, ores, and concentrates (3% less than that of 2015) (table 1). The leading end use of niobium was as an alloying element in high-strength low-alloy (HSLA) steel.

Because niobium resources in the United States are of low grade and not commercially recoverable at current prices, domestic supply has been a concern during every national military emergency since World War I. Materials from recycling and stocks are the only domestic supply sources of niobium.

Traded niobium materials included ferroniobium and niobium 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 potential upgrade or disposal under its fiscal year 2017 Annual Materials Plan (Defense Logistics Agency Strategic Materials, 2016a); however, the DLA Strategic Materials designated a ceiling quantity of 209 t of ferroniobium for acquisition (Defense Logistics Agency Strategic Materials, 2016b).

The U.S. Department of Labor identified coltan, a niobium- and tantalum-containing mineral, from Congo (Kinshasa) as a good produced by child labor and forced labor (U.S. Department of Labor, 2016, p. 30).

## Production

Globally, pyrochlore is the leading mineral mined for niobium. The primary marketable niobium materials were ferroniobium and niobium metal, ore, and oxide. In 2016, no domestic niobium mine production was reported.

NioCorp Developments Ltd. (Centennial, CO), a resource company developing its niobium deposit in Elk Creek, southeastern Nebraska, announced an agreement with CMC Cometals, a division of Commercial Metals Co. (Fort Lee, NJ), under which Cometals expected to purchase up to 1,875 metric tons per year (t/yr) of ferroniobium, for an initial 10-year term, from NioCorp's Elk Creek Superalloy Materials project (NioCorp Developments Ltd., 2016a, p. 7). Coupled with its previous purchase agreement with ThyssenKrupp Metallurgical

Products GmbH (Germany) for up to 3,750 t/yr of ferroniobium, NioCorp has about 75% of its potential planned ferroniobium production under sales contract. NioCorp completed a whole ore pre-leach (WPL) pilot plant as part of its feasibility study. The WPL plant treated approximately 1.34 t of ore material that was representative of the Elk Creek niobium resource, producing 485 kilograms (kg) of pre-leach residue containing between 1.24% and 1.95% niobium (NioCorp Developments Ltd., 2016d). The company also successfully completed pilot niobium production operations, producing kilogram quantities of niobium for use in the final testing of the company's ferroniobium production operation (NioCorp Developments Ltd., 2016c). NioCorp's continuous niobium optimization plant, the final metallurgical pilot plant planned in its Elk Creek feasibility study, produced niobium under continuous operating conditions at yearend 2016. The plant used a niobium-bearing solution, generated by treating a quantity of material from the Elk Creek resource using the company's pre-leach, acid bake, and water leach processes, and achieved an average of 97% niobium recovery over a 36-hour period (NioCorp Developments Ltd., 2016b). NioCorp planned to produce 7,490 t/yr of ferroniobium at the Elk Creek project (NioCorp Developments Ltd., 2016e, p. 18). In September, NioCorp completed a Jurisdictional Delineation process with the U.S. Army Corps of Engineers, clearing the path for the Elk Creek project to proceed to the next phase of planning and permitting (NioCorp Developments Ltd., 2016a, p. 8).

## 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, 26 responded to the "Consolidated Consumers" canvass, and 1 responded to the "Specialty Ferroalloys" canvass.

ATI Specialty Alloys and Components (Pittsburgh, PA; formerly ATI Wah Chang), Global Advanced Metals Pty Ltd. (Australia), and H.C. Starck GmbH (Germany) 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 metal, ore, and oxide. In 2016, the United States exported niobium materials valued at \$38.9 million (about 11% more than that of 2015) and imported niobium materials valued at \$382 million (about 8% less than that of 2015) (table 3).

## World Industry Structure

Brazil and Canada were the leading producers of niobium mineral ore and concentrates (table 4). In Brazil, the leading producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) (Araxá Mine) and Anglo American Nióbio Brasil Ltda. (a subsidiary of Anglo American plc) (Boa Vista Mine). In Canada, the leading producer was Niobec (a subsidiary of Magris Resources Inc.) (Niobec Mine).

Niobium ore was primarily mined in Brazil, Canada, China, and countries in the Great Lakes region of Africa. Niobium ore was typically beneficiated to concentrates containing about 55% to 60% niobium oxide ( $\text{Nb}_2\text{O}_5$ ) (Roskill Information Services Ltd., 2013, p. 9). Concentrates were further processed to produce ferroniobium or niobium metal. Ferroniobium, the leading commercial niobium-containing material, typically contained about 66% niobium and was consumed in the production of HSLA steel (Roskill Information Services Ltd., 2013, p. 12). Other uses included the fabrication of nonferrous and niobium alloys, and niobium carbides and chemicals.

## World Review

**Australia.**—Alkane Resources Ltd. announced that it has secured all required Federal and State government approvals and licenses for the development of their Dubbo zirconia project (DZP), in New South Wales, with final land acquisitions completed in June 2016 (Alkane Resources Ltd., 2016, p. 36). The DZP was being developed by Australian Zirconia Ltd., a wholly owned subsidiary of Alkane, on the basis of large in-ground resources of hafnium, niobium, rare-earth elements (REE), yttrium, and zirconium in the Toongi trachyte intrusive. Construction was expected to commence in 2017, contingent on financing (Alkane Resources Ltd., 2016, p. 3). The Toongi intrusive had proved and probable reserves of 36 million metric tons (Mt), as well as measured and inferred mineral resources of 73 Mt of hafnium-, niobium-, REE-, yttrium-, and zirconium-bearing trachyte with an average grade of 0.46 %  $\text{Nb}_2\text{O}_5$  (Alkane Resources Ltd., 2016, p. 18). The projected output at DZP, based on recoveries developed from mass balances of their demonstration pilot plant, was 1,970 t/yr of niobium as ferroniobium (65% Nb content) (Alkane Resources Ltd., 2016, p. 20).

**Brazil.**—Anglo American plc announced the completion of the sale of its niobium and phosphates businesses in Brazil to China Molybdenum Co., Ltd. (CMOC) (China), following the agreement announced in April 2016 (Anglo American plc, 2016). CMOC purchased Anglo American Fosfato Brasil Ltda. and Anglo American Nióbio Brasil Ltda. for approximately \$1.7 billion. The niobium business, renamed as Niobras

Mineração Ltda., included the Boa Vista Mine in the State of Goiás, along with three processing facilities, two non-operating mines, two mineral deposits, and the sales and marketing operations based in the United Kingdom and Singapore. All economic benefits of the businesses were transferred to CMOC at the end of September 2016 (Anglo American plc, 2016; China Molybdenum Co., Ltd., 2017, p. 98).

Mineração Taboca S.A., a subsidiary of MINSUR S.A. (Peru), operated the Pitinga-Pirapora Mine complex in Amazonas State and successfully implemented several productivity improvement projects. With the expansion of its tantalum and niobium ore sorting flotation plant, Taboca expected to increase production capacity by approximately 75% to 3,500 t/yr (MINSUR S.A., 2016). During 2016, Taboca changed its ferroalloy production from a single line of ferroniobium-tantalum alloy to separate ferroniobium and ferrotantalum alloys with higher contents of niobium and tantalum than that from the single line (MINSUR S.A., 2017, p. 42). In addition, Taboca finished reconstruction of the dike at its hydroelectric plant, which experienced problems in August 2015 that temporarily halted production.

**Canada.**—Commerce Resources Corp. completed a prospecting and sampling program at its Eldor Property in northern Quebec. Assay results of rock samples collected from the Miranna area returned niobium grades in excess of 0.5%  $\text{Nb}_2\text{O}_5$ , with a peak of 5.9%  $\text{Nb}_2\text{O}_5$ . In addition, significant grades of tantalum, ranging from 60 to 1,220 parts per million (ppm)  $\text{Ta}_2\text{O}_5$ , were returned from the same samples (Commerce Resources Corp., 2016).

In June, MDN Inc. acquired the rights of the James Bay niobium (Argor) property in northern Ontario from Barrick Gold Inc., Goldcorp Inc., and James Bay Columbium Ltd. (MDN Inc., 2016a). Historical estimates indicated niobium ore resources of approximately 62 Mt, grading 0.52%  $\text{Nb}_2\text{O}_5$ , at the James Bay property. MDN planned to review the existing historical data, and perform studies to validate the historical estimates. In September, MDN announced that the company changed its name to Niobay Metals Inc., following a consolidation of its common shares (MDN Inc., 2016b).

**Congo (Kinshasa).**—In mid-September, Congolese authorities cancelled the license of Société Minière du Kivu (SomiKivu), which managed the Lueshe Mine where pyrochlore concentrate (niobium oxide) is produced. The mine had been idle since 2004, and the license was due to expire in April 2017. Authorities cancelled the license owing to the absence of a compliant feasibility assessment and lack of proof of SomiKivu's financial capacity to operate the mine. SomiKivu is owned by AMG Advanced Metallurgical Group N.V. (70%, Germany), the Congolese Government (20%), and ConRus SPRL (10%, Russia) (Africa Mining Intelligence, 2016; Mining & Business Magazine, 2017).

**Estonia.**—Molycorp Silmet AS, a metals producer that specialized in the production of tantalum and niobium, was renamed NPM Silmet AS. The new business name was adopted in August 2016 after Molycorp Silmet's parent company, Molycorp Inc. (Greenwood Village, CO), emerged from Chapter 11 bankruptcy protection as a newly reorganized business, known as Neo Performance Materials Inc. (Canada) (Neo Performance Materials Inc., 2016).

**Malawi.**—Mkango Resources Ltd. (Canada) completed an airborne geophysical survey covering approximately two-thirds of the area in its Thambani massif license, in southern Malawi. Results confirmed the presence of a previously identified significant radiometric and magnetic anomaly, which provided focus for further investigation to determine whether the anomaly was related to mineralization. Columbite had previously been shown to be closely associated with magnetite-ilmenite at Thambani, and the first set of assay results of soil and rock chip samples returned variable niobium and tantalum values of as much as 3.25% Nb<sub>2</sub>O<sub>5</sub> in soil, and as much as 0.78% Nb<sub>2</sub>O<sub>5</sub> and 972 ppm Ta<sub>2</sub>O<sub>5</sub> in rock chips (Mkango Resources Ltd., 2016).

**Russia.**—China Machinery Engineering Corporation (China) and China National Electric Equipment Co., Ltd. (China) announced that they were ready to invest in the construction of a tantalum-niobium mining and concentration complex in the Zashikhinsky rare-metal granites massif, in the Irkutsk region of Siberia. The site, which was owned by CJSC Technoinvest Alliance, had estimated reserves of 34 Mt of ore with the potential to produce a concentrate containing 4.4% tantalum and 44% niobium (Gerden, 2015; Invest in Russia, 2016).

**Tanzania.**—Cradle Resources Ltd. (Australia) completed a definitive feasibility study for its Panda Hill niobium project, in the Myeba region. Cradle projected that the Panda Hill Mine would produce an average of 5,400 t/yr of contained niobium, amounting to approximately 8,200 t/yr of ferroniobium; the expected life of the mine was 30 years (Cradle Resources Ltd., 2016a, p. 1). The mine was expected to initially treat 1.3 million metric tons per year (Mt/yr) of ore, which would increase to 2.6 Mt/yr after the first 4 years of production. In June, Cradle reported proved reserves of 7.3 Mt of ore, with an average grade of 0.73% Nb<sub>2</sub>O<sub>5</sub>, and probable reserves of 13 Mt of ore, with an average grade of 0.65% Nb<sub>2</sub>O<sub>5</sub>, at Panda Hill (Cradle Resources Ltd., 2016b, p. 1). The Panda Hill Niobium project was owned by Panda Hill Tanzania Ltd, a 50–50 joint venture between Cradle and Tremont Investments Ltd. (Mauritius).

## Outlook

Currently operating niobium mines have adequate reserves. The mineral pyrochlore is the leading material mined for niobium. Potential new sources of niobium are typically associated with the production of other mineral deposits with niobium as a byproduct. Niobium minerals are typically converted to ferroniobium and other products at the mine site. The steel industry is the largest consumer of niobium, mainly for HSLA steel. The quantity of niobium used in HSLA steel per quantity of HSLA steel production is greatest in developed countries, indicating that there is potential for increasing niobium use in steel produced in developing nations (Roskill Information Services Ltd., 2013, p. 197–213). CBMM continued to be the leading producer of niobium mineral ore and concentrates, followed by Anglo American Nióbio Brasil Ltda. and Niobec. A number of potential new niobium sources were in development during 2016, including the Dubbo zirconia and Panda Hill projects. However, these projects were not expected to come into production in 2017, and thus no significant change in production distribution is anticipated.

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Tantalum-Niobium International Study Center.

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

|   |                      | 2012   | 2013                | 2014                | 2015                | 2016   |
|---|----------------------|--------|---------------------|---------------------|---------------------|--------|
| <b>United States:</b>   |                      |        |                     |                     |                     |        |
| <b>Exports:</b>   |                      |        |                     |                     |                     |        |
| Niobium ores and concentrates, gross quantity                     | metric tons          | 31     | 110                 | 60                  | 73                  | 14     |
| Synthetic ores and concentrates, gross quantity                   | do.                  | 209    | 61                  | 200                 | 138                 | 379    |
| Tantalum ores and concentrates, gross quantity                    | do.                  | 202    | 204                 | 225                 | 98                  | 162    |
| Niobium-containing ores and concentrates, <sup>2</sup> Nb content | do.                  | 53     | 53                  | 60                  | 42                  | 64     |
| Ferroniobium Nb content   | do.                  | 332    | 382                 | 1,050               | 1,390               | 1,410  |
| Total exports, Nb content   | do.                  | 385    | 435                 | 1,110               | 1,430               | 1,480  |
| <b>Imports for consumption:</b>                                   |                      |        |                     |                     |                     |        |
| Niobium ores and concentrates, gross quantity                     | do.                  | 11     | 8                   | 2                   | --                  | 1      |
| Synthetic ores and concentrates, gross quantity                   | do.                  | --     | --                  | --                  | --                  | 9      |
| Tantalum ores and concentrates, gross quantity                    | do.                  | 261    | 655                 | 897                 | 730                 | 675    |
| Niobium-containing ores and concentrates, <sup>2</sup> Nb content | do.                  | 32     | 75                  | 101                 | 82                  | 73     |
| Niobium metal, <sup>3</sup> Nb content                            | do.                  | 1,440  | 1,360               | 1,870               | 886                 | 1,230  |
| Niobium oxide, Nb content <sup>c</sup>                            | do.                  | 1,220  | 997                 | 1,020               | 983                 | 855    |
| Ferroniobium, Nb content <sup>c</sup>                             | do.                  | 7,430  | 6,140               | 8,120               | 6,570               | 6,080  |
| Total imports, Nb content   | do.                  | 10,100 | 8,580               | 11,100              | 8,520               | 8,230  |
| <b>Reported consumption, Nb content:</b>                          |                      |        |                     |                     |                     |        |
| Raw materials   | do.                  | W      | W                   | W                   | W                   | W      |
| Ferroniobium and nickel niobium                                   | do.                  | 7,460  | 7,500               | 8,210               | 7,510               | 7,370  |
| Apparent consumption, Nb content                                  | do.                  | 9,730  | 8,140               | 10,000              | 7,080               | 6,710  |
| <b>Value:<sup>4</sup></b>   |                      |        |                     |                     |                     |        |
| Niobium ores and concentrates                                     | dollars per kilogram | 23.54  | 17.15               | 14.94               | 7.59                | 7.83   |
| Niobium oxide   | do.                  | 44.43  | 43.47               | 37.04               | 36.19               | 33.66  |
| Ferroniobium  | do.                  | 27.63  | 27.29               | 25.78               | 24.27               | 20.71  |
| World, production of niobium concentrates, Nb content             | metric tons          | 62,700 | 59,300 <sup>r</sup> | 68,600 <sup>r</sup> | 63,300 <sup>r</sup> | 64,100 |

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

<sup>1</sup>Table includes data available through May 15, 2018. Data are rounded to no more than three significant digits, except values.

<sup>2</sup>Includes natural and synthetic niobium-containing ores and concentrates. Nb content of ore and concentrate was computed assuming the following Nb<sub>2</sub>O<sub>5</sub> contents: synthetic ore, 16%; niobium ore, 30%; and tantalum ore, 16%. Nb content of Nb<sub>2</sub>O<sub>5</sub> is 69.904%.

<sup>3</sup>Includes niobium and articles made of niobium.

<sup>4</sup>Weighted 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, niobium content)

|  | 2015                      | 2016         |
|--|---------------------------|--------------|
| End use:   |                           |              |
| Steel:   |                           |              |
| Carbon   | 1,280                     | 1,180        |
| Stainless and heat-resisting   | 712                       | 615          |
| Full alloy   | (2)                       | (2)          |
| High-strength low-alloy  | 800                       | 680          |
| Electric   | (2)                       | (2)          |
| Tool   | (2)                       | (2)          |
| Unspecified  | 3,080 <sup>r</sup>        | 3,100        |
| Total  | 5,870                     | 5,580        |
| Superalloys  | 1,620                     | 1,770        |
| Alloys (excluding steels and superalloys)  | 20                        | 21           |
| Grand total  | <u>7,510</u> <sup>r</sup> | <u>7,370</u> |
| Stocks, December 31:   |                           |              |
| Consumer   | 372 <sup>r</sup>          | 390          |
| Producer <sup>3</sup>  | W                         | W            |
| Total  | 372 <sup>r</sup>          | 390          |
| National Defense Stockpile, total uncommitted inventory by material,<br>niobium metal ingots | 1.71                      | 1.71         |

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Table includes data available through May 15, 2018. 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                                | 2015                          |                      | 2016                          |                      | Principal destinations and sources in 2016<br>(gross quantity in kilograms and values in thousand dollars) |
|---------------------------------|--------------------------------------|-------------------------------|----------------------|-------------------------------|----------------------|--|
|                                 |                                      | Gross quantity<br>(kilograms) | Value<br>(thousands) | Gross quantity<br>(kilograms) | Value<br>(thousands) |  |
| <b>Exports:</b>                 |                                      |                               |                      |                               |                      |  |
| 2615.90.3000                    | Synthetic concentrates               | 138,000                       | \$3,260              | 379,000                       | \$6,030              | China 153,000, \$839; Mexico 88,200, \$1,640; Hong Kong 71,900, \$1,860.                                   |
| 2615.90.6030                    | Niobium ores and concentrates        | 73,400                        | 557                  | 14,300                        | 103                  | Germany 4,740, \$33; India 4,250, \$30; United Kingdom 2,110, \$15.  |
| 2615.90.6060                    | Tantalum ores and concentrates       | 98,200                        | 4,860                | 162,000                       | 7,300                | Thailand 155,000, \$7,120; France 5,190, \$114; India 2,250, \$62.   |
| 7202.93.0000                    | Ferriobium                           | 2,140,000                     | 26,300               | 2,180,000                     | 25,500               | Canada 1,250,000, \$15,300; Mexico 913,000, \$10,000; Peru 9,270, \$102.                                   |
|                                 | Total exports                        | XX                            | 34,900 <sup>r</sup>  | XX                            | 38,900               |  |
| <b>Imports for consumption:</b> |                                      |                               |                      |                               |                      |  |
| 2615.90.3000                    | Synthetic concentrates               | --                            | --                   | 9,150                         | 46                   | Mexico 9,150, \$46.  |
| 2615.90.6030                    | Niobium ores and concentrates        | --                            | --                   | 1,160                         | 18                   | China 697, \$8; Canada, 467, \$10.   |
| 2615.90.6060                    | Tantalum ores and concentrates       | 730,000                       | 49,300               | 675,000                       | 37,300               | Brazil 440,000, \$26,000; Australia 97,900, \$3,900; Congo (Kinshasa) 83,300, \$4,410.                     |
| 2825.90.1500                    | Oxide                                | 1,410,000                     | 50,900               | 1,220,000                     | 41,200               | Russia 485,000, \$14,900; Brazil 463,000, \$17,500; Estonia 105,000, \$3,850.                              |
|                                 | Total ores, concentrates, and oxides | XX                            | 100,000              | XX                            | 78,500               |  |
| <b>Ferriobium:</b>              |                                      |                               |                      |                               |                      |  |
| 7202.93.4000                    | Silicon < 0.4%                       | 658,000                       | 28,500               | 1,560,000                     | 43,900               | Brazil 1,080,000, \$30,300; Finland 240,000, \$5,270; Germany 141,000, \$5,860.                            |
| 7202.93.8000                    | Other                                | 9,440,000                     | 242,000              | 9,290,000                     | 200,000              | Brazil 6,870,000, \$147,000; Canada 2,350,000, \$52,100; United Kingdom 25,600, \$500.                     |
|                                 | Total ferriobium                     | 10,100,000                    | 271,000              | 10,900,000                    | 244,000              |  |
| 8112.92.4000                    | Unwrought, powders <sup>3</sup>      | 886,000                       | 45,300 <sup>r</sup>  | 1,230,000                     | 58,700               | Brazil 1,130,000, \$53,600; Russia 37,700, \$1,650; Germany 25,000, \$1,450.                               |
|                                 | Total imports                        | XX                            | 416,000              | XX                            | 382,000              |  |

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

<sup>1</sup>Table includes data available through May 15, 2018. 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>Niobium waste and scrap is included in 8112.92.0600 along with 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 OR LOCALITY<sup>1,2</sup>

(Kilograms, niobium content)

| Country or locality <sup>3</sup>                       | 2012                 | 2013                    | 2014                    | 2015                    | 2016       |
|--|----------------------|-------------------------|-------------------------|-------------------------|------------|
| Brazil, mineral concentrate <sup>4</sup>               | 57,471,000           | 53,756,000 <sup>r</sup> | 62,055,000              | 57,343,000 <sup>r</sup> | 57,300,000 |
| Burundi, mineral concentrate <sup>c</sup>              | 51,000               | 14,000                  | 21,000                  | 10,000 <sup>r</sup>     | 8,000      |
| Canada, mineral concentrate <sup>4</sup>               | 4,705,000            | 4,916,000               | 5,774,000               | 5,385,000 <sup>r</sup>  | 6,213,000  |
| China, mineral concentrate <sup>c</sup>                | 14,680 <sup>r</sup>  | 15,379 <sup>r</sup>     | 19,573 <sup>r</sup>     | 30,059 <sup>r</sup>     | 30,000     |
| Congo (Kinshasa):                                      |                      |                         |                         |                         |            |
| Cassiterite concentrate                                | 80,000               | 70,000                  | 110,000                 | 90,000                  | 90,000     |
| Columbite-tantalite concentrate <sup>c</sup>           | 100,000              | 120,000                 | 230,000                 | 170,000                 | 150,000    |
| Ethiopia, columbite-tantalite concentrate <sup>c</sup> | 31,000 <sup>r</sup>  | 3,900 <sup>r</sup>      | 12,000 <sup>r</sup>     | 15,000 <sup>r</sup>     | 16,000     |
| Mozambique, mineral concentrate <sup>c</sup>           | 21,000               | 11,000                  | 5,700                   | 3,200 <sup>r</sup>      | 4,700      |
| Nigeria, columbite-tantalite concentrate <sup>c</sup>  | 26,000               | 38,000                  | 52,000                  | 52,000                  | 52,000     |
| Rwanda:  |                      |                         |                         |                         |            |
| Cassiterite concentrate                                | 50,000               | 50,000                  | 60,000                  | 40,000                  | 50,000     |
| Columbite-tantalite concentrate <sup>c</sup>           | 140,000 <sup>r</sup> | 310,000 <sup>r</sup>    | 290,000 <sup>r</sup>    | 210,000 <sup>r</sup>    | 190,000    |
| Uganda, mineral concentrate                            | --                   | --                      | --                      | 1,000 <sup>r, e</sup>   | 970        |
| Total  | 62,700,000           | 59,300,000 <sup>r</sup> | 68,600,000 <sup>r</sup> | 63,300,000 <sup>r</sup> | 64,100,000 |

<sup>c</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through November 23, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Figures for all countries represent marketable output.

<sup>3</sup>In addition to the countries and (or) localities listed, Australia, French Guiana, Malaysia, and Russia also produced or were thought to have produced niobium mineral concentrates, but available information was inadequate to make reliable estimates of output amounts.

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

TABLE 5  
 FERRONIObIUM (FERROCOlUMBIUM): WORLD PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Metric tons, niobium content)

| Country or locality <sup>2</sup> | 2012               | 2013                | 2014                | 2015                | 2016                |
|----------------------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| Brazil                           | 50,562             | 46,555 <sup>r</sup> | 51,737 <sup>r</sup> | 50,000 <sup>e</sup> | 50,000 <sup>e</sup> |
| Canada                           | 4,705 <sup>r</sup> | 4,916 <sup>r</sup>  | 5,774 <sup>r</sup>  | 5,385 <sup>r</sup>  | 6,213               |
| Russia                           | 420                | 360                 | 360                 | 360 <sup>r</sup>    | 360                 |
| Total                            | 55,700             | 51,800              | 57,900              | 55,700 <sup>r</sup> | 56,600              |

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

<sup>1</sup>Table includes data available through November 23, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

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