



2021 Minerals Yearbook

NIOBIUM [ADVANCE RELEASE]

NIOBIUM

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In 2021, U.S. niobium apparent consumption (measured in niobium content) was 7,280 metric tons (t), an increase of 15% compared with 6,320 t (revised) in 2020 (table 1). No domestic mine production of niobium ore was reported. The niobium content of world mine production was 87,600 t, 30% more than that in 2020 (tables 1, 4). The United States imported 8,290 t of niobium contained in niobium-bearing metal, alloys, and ores and concentrates, an increase of 15% compared with 7,200 t in 2020 (table 1). In 2021, the United States exported 1,010 t of niobium contained in niobium-bearing alloys and ores and concentrates, an increase of 27% compared with 793 t (revised) in 2020. World trade of niobium materials included ferroniobium and niobium metal, ores and concentrates, and scrap. Ferroniobium was the leading imported and exported niobium material in the United States in terms of value (table 3). The leading reported end use of niobium was as an alloying element in superalloys, followed by carbon steel and stainless and heat-resisting steel (table 2).

Government Actions and Legislation

The United States is heavily reliant on imports of certain mineral commodities vital to the Nation's security and economic prosperity. On May 18, 2018, under Executive Order 13817, the U.S. Department of the Interior published a list of 35 critical mineral commodities that included niobium. This dependency on foreign sources creates a strategic vulnerability for the U.S. economy and military to adverse foreign government action, natural disasters, and other events that can disrupt the supply of critical minerals (U.S. Department of the Interior, 2018). Niobium was first added to the U.S. Government stockpile in 1943 (as columbite ore), and the U.S. Congress designated niobium as a strategic and critical material in 1946 by means of the Strategic and Critical Materials Stock Piling Act as amended through P.L. 79-520, July 23, 1946 (DeMille, 1947, p. 135). The Defense Logistics Agency Strategic Materials, U.S. Department of Defense, did not designate niobium materials for potential acquisition or disposal from the National Defense Stockpile under its fiscal year 2022 Annual Materials Plan (Defense Logistics Agency Strategic Materials, 2021a, b).

Production

Globally, pyrochlore was the leading mineral mined for niobium. Niobium minerals typically were converted to ferroniobium and other value-added products at the mine site. The primary marketable niobium materials were ferroniobium and niobium metal, ore, and oxide. Niobium resources in the United States are of low grade and were not commercially recoverable at current prices and technology. As a result, domestic supply has been a concern during every national

military emergency since World War I. In 2021, no domestic niobium mine production was reported. Recycled materials and stocks were the only domestic sources of niobium.

NioCorp Developments Ltd. (Centennial, CO), a resource company developing a niobium deposit in Elk Creek, NE, announced that during the fiscal year ending June 30, 2021, it had purchased two land parcels and associated mineral rights in Johnson County, NE, for \$6.2 million. With this acquisition, NioCorp owned the surface land for the intended Elk Creek Project's mine infrastructure and support operations and gave NioCorp ownership of the mineral rights to more than 90% of the Elk Creek Project's reserves and estimated resources.

Additionally, NioCorp signed a contract with Cementation USA, Inc., Elk Creek's lead contractor for the underground aspects, to evaluate the current underground mine design and compose a cost estimate for the engineering required to develop the mine (NioCorp Developments Ltd., 2021, p. 1, 37). When active, the mining operation was expected to produce 169,000 t of payable niobium content of ferroniobium, 3,410 t of scandium oxide, and 419,000 t of titanium dioxide over a 36-year mine life (NioCorp Developments Ltd., 2019, p. 31, 68).

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.

Total domestic apparent consumption of niobium was 7,280 t in 2021, a 15% increase compared with that in 2020 (revised) (table 1). Reported consumption of niobium by the steel industry was 4,620 t in 2021, a slight increase compared with 4,520 t in 2020 (revised) (table 2). Ferroniobium, the leading niobium material consumed in the United States, was typically used in the production of high-strength low-alloy (HSLA) steel and stainless steel. Other uses of niobium included the fabrication of nonferrous and niobium alloys, superalloys, and production of niobium carbides and chemicals.

Prices

Niobium materials were not openly traded on exchanges. Purchase contracts were confidential between buyer and seller. Based on U.S. Census Bureau data for 2021, the average unit value of traded (imported plus exported) niobium-containing materials was \$35.52 per kilogram for niobium ores and concentrates (a 33% increase compared with that in 2020), \$34.20 per kilogram for niobium oxide (Nb₂O₅) (a slight increase compared with that in 2020), and \$20.83 per kilogram for ferroniobium (unchanged compared with that in 2020) (tables 1, 3).

Foreign Trade

According to the U.S. Census Bureau, the United States exported niobium materials valued at \$26.7 million in 2021 (a 68% increase compared with that in 2020) and imported niobium materials valued at \$369 million (a 25% increase compared with that in 2020) (table 3). Traded niobium materials included ferroniobium and niobium metal, ores and concentrates, and oxide. In 2021, exports of ferroniobium increased by 24% compared with those in 2020, and imports for consumption increased by 14%. Ferroniobium was the leading niobium material traded by value, accounting for 57% of the total import value and 59% of the total export value. In 2021, Brazil continued to be the leading supplier of ferroniobium and niobium metal and oxides (table 3). In terms of volume, Mexico was the leading destination of ferroniobium exports from the United States, followed by Canada.

World Industry Structure

Niobium ore was mined primarily in Brazil, Canada, and countries in the Great Lakes region of Africa, including Congo (Kinshasa) and Rwanda, and was typically beneficiated to concentrates containing 55% to 60% Nb₂O₅. Concentrates were further processed to produce ferroniobium or niobium metal and oxides. Ferroniobium, the leading commercial niobium-containing material, typically contained about 66% niobium (Roskill Information Services Ltd., 2021, p. 72).

In 2021, world production of niobium contained in cassiterite, columbite-tantalite, loparite, and pyrochlore concentrates was 87,600 t (table 4), an increase of 30% compared with that in 2020. World production of ferroniobium, in terms of niobium content, was estimated to be 74,800 t, a 15% increase from that in 2020 (table 5). Brazil and Canada were the leading producers of ferroniobium (table 5) and niobium mineral concentrates (table 4), accounting for more than 99% of global ferroniobium production and 99% of global niobium mineral concentrates production.

In Brazil, the leading producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) and Niobras Mineração Ltda. [a subsidiary of China Molybdenum Co., Ltd. (China)]. In Canada, the leading producer was Niobec Inc. (a subsidiary of Magris Resources Inc.).

World Review

Australia.—Australian Strategic Materials Ltd. (ASM) demerged from Alkane Resources Ltd. and retained all interests and associated assets in the Dubbo Project in Toongi, New South Wales State, in July. The Dubbo Project contains hafnium, niobium, rare-earth elements (including yttrium), and zirconium resources. ASM intended to develop the project to produce oxides onsite for refining into critical metals at its metals plant in the Republic of Korea under ASM's subsidiary Rare Metals Resources Technology Corp. The project was development ready, subject to financing, with the mineral deposit and surrounding land acquired, all major State and Federal approvals in place, and piloting and engineering studies complete. According to the company's 2021 mineral resource estimate, total measured and indicated resources at the Dubbo Project

were estimated to be 75 million metric tons (Mt) grading 0.44% Nb₂O₅ and 0.03% Ta₂O₅, supporting a potential 75-year mine life at an ore-processing rate of 1 million metric tons per year (Australian Strategic Materials Ltd., 2021, p. 17, 20, 29).

Brazil.—CBMM reported that it produced 99,710 t in gross weight of niobium products in 2021, including 91,920 t of ferroniobium, at its mining and industrial complex in Araxa, Minas Gerais State. This production represented a 34% increase from the 74,220 t of niobium products produced in 2020. In November, CBMM inaugurated its newest facilities in Araxa, increasing the company's total production capacity of ferroniobium equivalent to 150,000 metric tons per year (t/yr) from 100,000 t/yr. CBMM announced plans to invest \$1.7 billion¹ in its production assets to double its sales volume by 2030 (Companhia Brasileira de Metalurgia e Mineração, 2022, p. 18, 35).

Mineração Taboca S.A. [a subsidiary of MINSUR S.A. (Peru)] operated the Pitinga-Pirapora Mine complex in Amazonas State. In 2021, the company reported production of 4,003 t in gross weight of niobium and tantalum ferroalloys, a 15% increase compared with 3,484 t in 2020. MINSUR reported that the production increase was due to improvements in recovery of niobium and tantalum at the metallurgical plant and more days of continuous operation compared with those in 2020 (MINSUR S.A., 2021, p. 9).

Niobras Mineração, a subsidiary of China Molybdenum, operated the Boa Vista Mine and ferroalloy plant in Goiás State. In 2021, China Molybdenum reported that it produced 8,586 t of niobium contained in ferroniobium, an 8% decrease compared with 9,300 t in 2020 (China Molybdenum Co., Ltd., 2022, p. 17).

In January 2021, AMG Advanced Metallurgical Group N.V. (Netherlands) restructured into three operating segments, with tantalum and niobium falling under AMG Clean Energy Materials (AMG Advanced Metallurgical Group N.V., 2022, p. 30). Niobium concentrate production at its Mibra lithium-tantalum-niobium-tin mine in Minas Gerais State was not disclosed for 2019, 2020, and 2021.

Canada.—In March, Canada's Minister of Natural Resources announced the release of Canada's list of critical minerals. This list consisted of 31 minerals, including tantalum and niobium, considered critical for the sustainable economic success of Canada and its allies (Natural Resources Canada, 2021).

NioBay Metals Inc., owner of the James Bay Niobium Project located in Ontario Province and 70% owner of the Crevier Project located in Quebec Province, announced a renewed and restated Protection Agreement with the Moose Cree First Nation and received an exploration drilling permit issued by the Ministry of Energy Northern Development and Mines in the Moose Cree Traditional Territory of the James Bay Lowlands in Ontario Province. The permit was valid for 3 years to drill up to 20,000 meters or approximately 20 to 30 holes (NioBay Metals Inc., 2021a). In May, Niobay announced an option agreement with Les Ressources Tectonic Inc. to acquire a 100% interest in two niobium-containing properties located south of Chibougamau, Quebec Province (NioBay Metals Inc., 2021b).

¹Where necessary, values have been converted from Brazilian real (BRL) to U.S. dollars (US\$) at an annual average exchange rate of BRL5.395=US\$1.00 for 2021.

According to a 2020 mineral resource estimate, indicated resources at the James Bay Niobium Project were estimated to be 29.7 Mt grading 0.53% Nb₂O₅ for 158,000 t of niobium, using a cutoff grade of 0.3% Nb₂O₅. Mine life was projected to be 30 years (NioBay Metals Inc., 2020, p. 14–1). According to a 2010 mineral resource estimate, total measured and indicated resources at the Crevier Project were estimated to be 25 Mt grading 0.20% Nb₂O₅ and 0.02% Ta₂O₅, using a cutoff grade of 0.1% Nb₂O₅. Mine life was expected to be 25 years (NioBay Metals Inc., 2010, p. 11). Neither project was active in 2021.

Colombia.—In 2021, Colombian law enforcement authorities seized approximately 8 t of columbite-tantalite (coltan) from armed groups. The coltan was believed to be sourced illegally from the Puinawai Forest Reserve in the Department of Guainia and Venezuela's Orinoco Mining Arc, where the borders of Brazil, Colombia, and Venezuela converge. The coltan was then believed to be smuggled to cities like Bogota and Villavicencio to be sold internationally (Jaramillo, 2021).

Russia.—LLC Lovozero GOK operated the Lovozero Mine in Murmansk Province. The company produced loparite mineral concentrates consumed by the JSC Solikamsk Magnesium Works (SMZ) facility to produce niobium compounds in Perm Kray. Niobium concentrate production was not disclosed for 2021.

Tanzania.—In June, Cradle Resources Ltd. reported the demerger and process of transferring its 37.2% interest in the Panda Hill Niobium Project in Tanzania to Panda Hill Mining Ltd., with Tremont Investments Ltd. holding the 62.8% interest (Cradle Resources Ltd., 2021, p. 1–2). According to a 2016 Definitive Feasibility Study, the deposit's estimated measured, indicated, and inferred resources were 178 Mt, grading 0.50% Nb₂O₅ (Cradle Resources Ltd., 2016).

Outlook

Currently, operating niobium mines have adequate reserves to meet global demand for the foreseeable future. The steel industry is the largest consumer of niobium (mainly in HSLA steel), and niobium content of HSLA steel is greatest in developed countries, indicating that niobium use in steel could increase in developing nations. Potential new sources of niobium typically are associated with the production of other mineral deposits with niobium as a byproduct. Several potential new niobium sources were in development during 2021, mostly in Australia and Canada.

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TABLE 1
 SALIENT NIOBIUM STATISTICS¹

(Metric tons unless otherwise specified)

	2017	2018	2019	2020	2021	
United States:						
Exports:						
Niobium ores and concentrates, gross weight	7	5	27	4	5	
Synthetic concentrates, gross weight	113	198	40	120	238	
Tantalum ores and concentrates, gross weight	109	48	28	10	180	
Niobium-containing ores and concentrates, ² niobium (Nb) content ^c	26	28	13	15	48	
Ferroniobium, Nb content ^c	1,460	926	655	777 ^r	962	
Total exports, Nb content	1,490	955	668	793 ^r	1,010	
Imports for consumption:						
Niobium ores and concentrates, gross weight	1	31	3	4	1	
Synthetic concentrates, gross weight	15	12	6	6	30	
Tantalum ores and concentrates, gross weight	1,010	1,050	840	693	1,300	
Niobium-containing ores and concentrates, ² Nb content ^c	115	126	95	79	149	
Niobium metal, Nb content ³	1,410	1,800	1,690 ^r	1,220	1,250	
Niobium oxide, Nb content ^c	895	964	994	519	750	
Ferroniobium, Nb content ^c	6,910	8,290	7,330	5,380	6,140	
Total imports, Nb content	9,330	11,200	10,100	7,200	8,290	
Reported consumption, Nb content:						
Raw materials	W	W	W	W	W	
Ferroniobium and nickel niobium	7,640	6,850	6,680	6,040 ^r	6,140	
Apparent consumption, Nb content ⁴	7,780	10,100	9,360 ^r	6,320 ^r	7,280	
Unit value, ⁵ gross weight:						
Niobium ores and concentrates	dollars per kilogram	20.69	15.08	11.33	26.62	35.52
Niobium oxide	do.	31.20	35.03	35.42	33.58	34.20
Ferroniobium	do.	19.83	21.11	22.71	20.74 ^r	20.83
World, production of niobium concentrates, Nb content ⁶	66,800	78,700 ^r	96,900 ^r	67,500 ^r	87,600	

^cEstimated. ^rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through July 11, 2022. Data are rounded to no more than three significant digits, except unit values; may not add to totals shown.

²Includes natural and synthetic niobium-containing ores and concentrates. Niobium (Nb) content of ores and concentrates is estimated assuming the following niobium oxide (Nb₂O₅) contents: 30% in niobium ore, 16% in synthetic concentrates, and 16% in tantalum ore. Nb₂O₅ is 69.904% Nb.

³Includes niobium and articles made of niobium.

⁴Defined as imports minus exports plus adjustments for Government stock changes.

⁵Weighted average unit value of imported plus exported materials.

⁶May include estimated data.

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

TABLE 2
 REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIUM AND
 NICKEL NIOBIUM, AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES¹

(Metric tons, niobium content)

	2020	2021
End use:		
Steel:		
Carbon	937 ^r	987
Stainless and heat-resisting	422 ^r	479
Full alloy	285 ^r	282
High-strength low-alloy	(2)	(2)
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	2,870 ^r	2,870
Total	4,520 ^r	4,620
Superalloys	1,500 ^r	1,500
Alloys (excluding steels and superalloys)	18 ^r	18
Grand total	<u>6,040 ^r</u>	<u>6,140</u>
Stocks, December 31:		
Consumer	555 ^r	566
Producer ³	W	W
Total	555 ^r	566
National Defense Stockpile, total uncommitted inventory by material:		
Ferroniobium	353	354
Niobium metal ingots	10	10

^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through July 11, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.

²Withheld to include company proprietary data; included with "Steel: Unspecified."

³Ferroniobium only.

TABLE 3
U.S. FOREIGN TRADE IN NIOBIUM, BY CLASS¹

Categorization code ²	Class	2020		2021		Principal destinations and sources in 2021 (gross weight in metric tons and values in thousand dollars)
		Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)	
Exports:						
2615.90.3000	Synthetic concentrates	120	\$2,110	238	\$2,700	Germany 96, \$932; Taiwan 78, \$83; Mexico 54, \$1,550.
2615.90.6030	Niobium ores and concentrates	4	126	5	149	India 3, \$101; United Kingdom 1, \$23; China 1, \$20.
2615.90.6060	Tantalum ores and concentrates ³	10	525	180	8,160	Thailand 172, \$7,670.
7202.93.0000	Ferriobium	1,200 ⁴	13,100	1,480	15,700	Mexico 1,037, \$11,100; Canada 321, \$3,220.
	Total exports	XX	15,900	XX	26,700	
Imports for consumption:						
2615.90.3000	Synthetic concentrates	6	199	30	931	Singapore 28, \$921.
2615.90.6030	Niobium ores and concentrates	4	97	1	85	China 1, \$48.
2615.90.6060	Tantalum ores and concentrates ³	693	29,800	1,300	62,700	Australia 567, \$27,500; Congo (Kinshasa) 21, \$12,800; Mozambique 170, \$8,200.
2825.90.1500	Niobium oxide	743	24,900	1,070	36,700	Brazil 844, \$29,100; Thailand 109, \$3,340; Estonia 84, \$2,650.
	Total ores, concentrates, and oxides	XX	55,000	XX	100,000	
Ferriobium:						
7202.93.4000	Silicon <0.4%	75	2,330	--	--	XX.
7202.93.8000	Other	8,210	181,000	9,450	212,000	Brazil 6,330, \$137,000; Canada 3,040, \$74,400.
	Total ferriobium	8,280	184,000	9,450	212,000	
8112.92.4000	Unwrought, powders ⁴	1,220	56,800	1,250	56,700	Brazil 900, \$40,000; Russia 268, \$10,500.
	Total imports	XX	295,000	XX	369,000	

¹Revised. XX Not applicable. -- Zero.

²Table includes data available through June 16, 2022. Data are rounded to no more than three significant digits; may not add to totals shown.

³Exports categorized as United States Schedule B. Imports categorized as Harmonized Tariff Schedule of the United States (HTS).

⁴Tantalum ores and concentrates may contain niobium.

⁵Niobium waste and scrap, as well as other materials, is included in HTS code 8112.92.0600. Niobium other than powders, unwrought, and waste and scrap is included in HTS code 8112.99.9000 along with other materials.

Source: U.S. Census Bureau.

TABLE 4
NIOBIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY OR LOCALITY^{1,2}

(Metric tons, niobium content)

Country or locality ³	2017	2018	2019	2020	2021
Brazil:					
Columbite-tantalite concentrate	1,892	2,682	2,559	2,495	2,655
Pyrochlore concentrate	56,244	66,910	86,374	57,324	76,075
Total	58,136	69,592	88,933	59,819	78,730
Burundi, ore and concentrate ^c	28	43	38	30 ^r	39
Canada, pyrochlore concentrate	7,200	7,600 ^{r,e}	6,800 ^e	6,400 ^{r,e}	7,500 ^e
China, mineral concentrate	45	45	45 ^e	44	45 ^e
Congo (Kinshasa):^e					
Cassiterite concentrate	180	160	180	260	290
Columbite-tantalite concentrate	380	400	230	300	290
Total	560	560	410	560	580
Ethiopia, columbite-tantalite concentrate ^c	22	26	7	7	12
Mozambique, columbite-tantalite concentrate	4 ^e	5 ^e	6 ^e	9	8 ^e
Nigeria, columbite-tantalite concentrate ^c	63	89	40 ^r	50 ^r	40
Russia, loparite concentrate	453	467	461	432 ^r	450 ^e
Rwanda:^e					
Cassiterite concentrate	43 ^r	43 ^r	35	26	28
Columbite-tantalite concentrate	210 ^r	210	170	130	130
Total	253 ^r	253 ^r	205	156	158
Uganda, ore and concentrate ^c	(4) ^r	(4) ^r	(4) ^r	7 ^r	7
Grand total	66,800	78,700^r	96,900^r	67,500^r	87,600

^cEstimated. ^rRevised.

¹Table includes data available through August 10, 2022. All data are reported unless otherwise noted; totals may include estimated data.

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

²Figures for all countries and (or) localities represent marketable output.

³In addition to the countries and (or) localities listed, Australia, French Guiana, and Malaysia may have produced niobium mineral concentrates, but available information was inadequate to make reliable estimates of output.

⁴Less than ½ unit.

TABLE 5
FERRONIBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons, niobium content)

Country or locality ²	2017	2018 ^e	2019 ^e	2020 ^e	2021 ^e
Brazil	58,690	59,000	60,000	58,300	67,000
Canada	6,981	7,400	6,600 ^r	6,200	7,400
Russia	240	290	400	370 ^r	350
Total	65,900	66,700	67,000 ^r	64,900	74,800

^eEstimated.

¹Table includes data available through July 18, 2022. All data are reported unless otherwise noted; totals may include estimated data.

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

²In addition to the countries and (or) localities listed, Austria, China, and Germany may have produced ferroniobium (ferrocolumbium), but available information was inadequate to make reliable estimates of output.