2012 Minerals Yearbook

NIOBIUM AND TANTALUM [ADVANCE RELEASE]

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Niobium (Columbium) and Tantalum

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In 2012, U.S. niobium apparent consumption (measured in contained niobium) was 9,734 metric tons (t), 6% more than that of 2011; U.S. tantalum apparent consumption (measured in contained tantalum) was 437 t, 64% less than that of 2011. No domestic mine production of niobium or tantalum ore was reported. Compared to that of the previous year, world production of niobium ore increased 2%, while tantalum ore production increased 21%; U.S. imports of tantalum ore increased 37%, while exports increased 91%. The leading use of niobium was as an alloying element in high-strength low-alloy (HSLA) steel. The leading use of tantalum was in electronic capacitors.

Because the United States has no niobium or tantalum reserves, domestic supply has been a concern during every national military emergency since World War I. World niobium and tantalum resources and mining capacity are geographically concentrated in Brazil (niobium and tantalum) and Canada (niobium) in the Western Hemisphere and Australia (tantalum), Congo (tantalum), and Mozambique (tantalum) in the Eastern Hemisphere. World niobium and tantalum reserves are adequate to meet anticipated world demand. Materials from recycling and stocks are the only domestic supply sources of niobium and tantalum.

Traded tantalum materials included tantalum ore and concentrate, slags, potassium heptafluorotantalate (commercially known as, K-salt), chemicals, metal, scrap, and residue.

Legislation and Government Programs

The Defense Logistics Agency, Strategic Materials (DLA) did not designate niobium or tantalum materials for disposal under its fiscal year 2012 and 2013 Annual Materials Plans (Defense Logistics Agency—Strategic Materials, 2012).

Tantalum was identified as a "conflict mineral" by the Dodd-Frank Wall Street Reform and Consumer Protection Act. The U.S. Securities and Exchange Commission (SEC) (2012) ruled that United States-listed companies that use conflict minerals must report annually whether any of those minerals originated in the Democratic Republic of the Congo or an adjoining country.

Production

The major marketable niobium materials are ferroniobium and niobium metal, ore, and oxide. The major marketable tantalum materials are tantalum metal (unwrought and wrought alloys, metal, and powder), ore, and scrap. In 2012, neither niobium nor tantalum domestic mine production was reported.

NioCorp Developments Ltd., formerly Quantum Rare Earth Developments Corp., reported 19.3 million metric tons (Mt) of indicated resources at 0.67% niobium pentoxide (Nb_2O_5)* and 83.3 Mt of inferred resources at 0.63% Nb_2O_5* to a cutoff grade of 0.40% Nb_2O_5 at its Elk Creek, NE, property. Elk Creek was thought to be the only primary niobium deposit being developed in the United States (NioCorp Developments Ltd., undated; 2013).

Consumption

Domestic data for niobium and tantalum materials were developed by the USGS by means of the "Columbium (Niobium) and Tantalum," "Consolidated Consumers," and "Specialty Ferroalloys" surveys. For niobium and tantalum materials, one consumer responded to the "Columbium (Niobium) and Tantalum" canvass, about 70 responded to "Consolidated Consumers" canvass, and one responded to the "Specialty Ferroalloys" canvass. The steel industry accounted for 79% of niobium and tantalum reported consumption; the superalloy industry, 21%.

Niobium ore was beneficiated to concentrates containing about 54% Nb_2O_5. Nb_2O_5 was produced from the concentrate; ferroniobium or niobium metal, from Nb_2O_5. Ferroniobium, the leading commercial niobium-containing material, was typically about 60% niobium, and was consumed in the production of HSLA steel. Other uses included the production of niobium carbide and chemicals. The use of niobium-containing steel in automobiles results in greater fuel efficiency (Lowder, 2012).

Tantalum was used by the chemical processing, cutting tool, electronics, medical, and optical and X-ray equipment industries (Stratton and Henderson, undated). The electronics industry was the leading tantalum consumer, and electronic capacitors were the leading electronic use. Tantalum provides high dielectric constant and oxide layer stability to tantalum capacitors which results in high volumetric and thermally stable capacitance, which are desirable characteristics in some applications. Bioinertness makes tantalum useful in biomedical and surgical applications. Ductility and corrosion resistance make tantalum mill products useful in chemical processing. High-temperature strength and high melting points of tantalum and tantalum alloys make tantalum useful in superalloys. A wide variety of tantalum chemical uses take advantage of specific properties. For instance, tantalum pentoxide usage in glass increases the refractive index of the glass, tantalum carbide in cemented carbide cutting tools increases their toughness, and the inertness of tantalum nitride contributes to its use for diffusion barriers in microelectronic circuits (Espinoza, 2012).

Schwela (2012) reported world niobium and tantalum consumption by material. Tantalum consumption, based on tantalum processors' shipments, was capacitor-grade tantalum powder (24%); metallurgical-grade powder, unwrought

*Corrections posted May 30, 2014.

metal, scrap, and other (11%); mill products of tantalum (16%); tantalum carbide (7%); tantalum chemicals (36%); and tantalum ingot (6%). Niobium consumption, based on niobium processors' shipments, was niobium alloys (1.9%); niobium chemicals (4.5%); niobium metal (1.2%); steel-grade ferroniobium (88.8%); and vacuum-grade niobium (3.6%). Niobium masteralloys—ferroniobium and niobium-nickel alloy—were consumed to produce steel and superalloys. About 75% of world niobium consumption was for the production of microalloyed steel (Companhia Brasileira de Metalurgia e Mineração, undated c).

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

Prices

Niobium and tantalum materials were not openly traded. Purchase contracts were confidential between buyer and seller; however, trade journals reported composite prices of tantalite based on interviews with buyers and sellers, and traders declared the value of niobium and tantalum materials that they imported or exported. In 2012, the annual average price of tantalite ore per pound of contained tantalum oxide (Ta_2O_5) was $108.469. The tantalite ore price decreased to $90 in May 2012, rose to $121.944 in October, and closed the year at $120.000.

Foreign Trade

Niobium and tantalum material exports from and imports to the United States included ferroniobium and niobium chemicals, metal, ore, and oxide, and tantalum metal and ore. In 2012, the values of foreign trade of these niobium and tantalum materials were $161 million for exports (11% less than that of 2011) and $772 million for imports (20% greater than that of 2011).

The United States exported 385 t of niobium contained in niobium materials (6% greater than that of 2011) and imported 10,100 t of niobium contained in niobium materials (6% greater than that of 2011) (table 1). The United States exported 577 t of tantalum contained in tantalum materials (11% less than that of 2011) and imported 1,014 t of tantalum contained in tantalum materials (45% less than that of 2011) (table 2).

World Industry Structure

Brazil and Canada were the leading producers of niobium mineral concentrates; Brazil and Rwanda were the leading producers of tantalum mineral concentrates (table 6). Tantalum-bearing tin slags, which are byproducts from tin smelting, principally from Asia, Australia, and Brazil, were another source of tantalum. The leading niobium ore and concentrate producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) in Brazil and IAMGOLD Corp. at its Niobec Mine in Canada. The leading tantalum ore and concentrate producers were Metalurg Group (Mibra Mine) and Mineração Taboca S/A (Pitinga Mine) in Brazil and Noventa Ltd. (Morropino Mine) in Mozambique.

The vast majority of world niobium production resulted from mining the mineral pyrochlore in Brazil and Canada. Steelmaking, primarily HSLA and stainless steels, accounted for about 90% of niobium use. Niobium-containing HSLA steel was used in automobiles, construction, and gas pipelines; stainless steel was used in automobiles (Roskill Information Services Ltd., 2009, p. 1–3).

About 74% of tantalum world supply resulted from the mine production of tantalum-containing minerals with an additional 8% from slags and synthetic concentrates and the remaining 18% from recycling (Roskill Information Services Ltd., 2012, p. 17).

The Tantalum-Niobium International Study Center reported annual niobium and tantalum primary production based on a survey of its members. Tantalum primary production from tantalum concentrates, tin slags, and other concentrates was estimated to have been 600 t of contained tantalum in 2011, the most recent year for which data were available. Niobium primary production from niobium concentrates and other concentrates containing more than 2% niobium pentoxide (Nb_2O_5) was estimated to have been 64,000 t of contained niobium in 2011 (Tantalum-Niobium International Study Center, 2012).

Niobium

Leading world ferroniobium producers were CBMM, Mineração Catalão de Goias (Brazil), and IAMGOLD Corp. (Canada), which collectively accounted for 123,700 metric tons per year (t/yr) of ferroniobium production capacity that was expected to increase to 193,000 t/yr of ferroniobium by 2017. World ferroniobium consumption was more than 80,000 t in 2011, and from 2000 through 2011, the ferroniobium consumption trend generally followed the world steel production trend (Dufresne, 2012).

Niobium ore grade at deposits mined in 2011 ranged from 0.59% Nb_2O_5 in Canada to 3% Nb_2O_5 in Brazil, Congo (Kinshasa), and Russia (British Geological Survey, 2011, p. 1, 3–4, 10–12). Brazil has been the leading niobium producer and Canada has been the second-ranked producer in since 1997.

Tantalum

World tantalum resources were reported to have been about 260,000 t of tantalum distributed among Australia (21%); Brazil (40%); central Africa (10%); and other Africa, Asia, and Europe (29%). Tantalum's country production concentration was moderate but increasing. Tantalum production capacity was 574 t/yr, measured in tantalum content, and was expected to increase to 1,002 t/yr in 2013 and to 1,084 t/yr in 2015. The additional 428 t/yr expected annual production capacity addition in 2013 was to have been from the ramp up of capacity expansion or reopening in Australia, Brazil, and Mozambique (Polinares Consortium, 2012).

World Review

Australia. —The Government of Australia reported that, as of December 31, 2011, Joint Ore Reserves Committee (JORC)-

compliant ore reserves (as stated in company annual reports and reports to the Australian Stock Exchange) were 115,000 t for niobium and 29,000 t for tantalum. Accessible economic demonstrated resources for niobium were 205,000 t and 62,000 t for tantalum (Geoscience Australia, 2013).

Alkane Resources Ltd. planned to complete a definitive feasibility study on its Dubbo Zirconia Project in New South Wales in 2013 with updated capital and operating costs for the production of 1 Mt/yr of ore. By producing 1 Mt/yr of ore, Alkane could produce 3,000 t/yr of niobium-tantalum concentrates. Alkane reported 35.93 Mt of reserves at 0.46% Nb_2O_5 and 0.03% tantalum pentoxide (Ta_2O_5)* contained in 73.20 Mt of resources at the same grades. Alkane planned to start ore production in 2016 (Alkane Resources Ltd., 2013, p. 5, 7, 10).

In Western Australia, GAM produced tantalum ore at Wodgina Mine and processed it along with tantalum ore from Galaxy Resources Ltd.'s Mt. Cattlin operation into concentrate at GAM's Greenbushes processing plant. Wodgina's production capacity of Ta_2O_5 contained in concentrate was 635 t/yr of which one-half was committed for contracts. GAM processed conflict-free tantalum concentrate in Japan and the United States to produce tantalum products, including tantalum powder, tantalum metallurgical products, and niobium metallurgical products (Global Advanced Metals Pty. Ltd., 2012). GAM Resources Perth suspended mine production in 2012.

Galaxy Resources shipped 638 t of tantalum concentrate in 2012 from Mt. Cattlin to GAM's Greenbushes processing plant. Galaxy suspended production at Mt. Cattlin to permit processing of spodumene stocks, Mt. Cattlin's primary product, which had built up at Galaxy's Jiangsu, China, lithium carbonate plant. Galaxy reported reserves at Mt. Cattlin of 10.737 Mt containing 146 g/t (0.0146%) Ta_2O_5 and resources of 17.155 Mt containing 155 g/t (0.0155%) Ta_2O_5 to a cutoff grade of 0.4% lithium oxide as of 2011 (Galaxy Resources Ltd., 2013, p. 2, 9).

Lithex Resources Ltd. reported 1.9 Mt of inferred resources containing 20 g/t tantalum in tin mine tailings stockpiles at its Moolyella project with preliminary recovery results of 66.3%. The tailings were from tin mining that took place from 1898 to 1986. Lithex was also considering options for tantalum production at its Pilgangoora and Arthur River projects (Lithex Resources Ltd., 2012, undated).

Brazil.—Niobium mine production in Brazil was 165,723 t of contained Nb_2O_5 from reserves of 4,133,193 t Nb_2O_5 in 2011. Final products were 64,657 t of Nb_2O_5 contained in concentrate, 53,691 t of niobium contained in ferroniobium, and 4,388 t of Nb_2O_5 (Pereira and da Rosa, 2012, p. 93–94). Brazilian tantalum mine production was 136 t of tantalum contained in concentrate from reserves of 36,000 t of tantalum in 2011 (Pontes, 2012, p. 111–112).

Anglo American Brazil Ltd. (a subsidiary of Anglo American plc) mined pyrochlore from a carbonatite deposit. The Catalão Mine comprised three open pits and a processing facility near the city of Catalão, Goiàs State. Anglo reported production of 4,400 t of niobium contained in ore in 2012 compared with 3,900 t in 2011. The company mined 933,000 t of ore and processed 974,000 t of ore at 8.5 kilograms per ton (kg/t) of niobium (or 0.85% Nb). In 2012, Anglo reported reserves of 5.9 Mt at 0.93% Nb_2O_5 containing 38,000 t of niobium contained in resources of 75.5 Mt at 1.13% Nb_2O_5 containing 595,000 t of niobium (Anglo American plc, 2013, p. 17, 88, 198, 234). Anglo planned to bring the Boa Vista Fresh Rock project into production in 2014, which would bring their niobium production capacity to 6,500 t/yr of contained niobium in 2015 from 4,400 t /yr in 2012.

CBMM mined niobium ore from the Barreiro carbonatite complex near Araxá, Minas Gerais State, and beneficiated the ore at the mine site by selectively extracting the pyrochlore minerals from which niobium oxide is produced. The deposit contained 440 Mt of reserves at an average grade of 2.5% to 3% Nb_2O_5 that could be mined by open pit methods (Riffel, undated). CBMM produced ferroniobium, nickel-niobium, niobium metal, niobium oxide, and high-purity ferroniobium, and had production capacities of 70,000 t/yr of ferroniobium, 3,000 t/yr of high-purity ferroniobium and nickel-niobium, and 210 t/yr of niobium metal (Companhia Brasileira de Metalurgia e Mineração, undated a, b). A consortium of Chinese companies including Citic Group, Anshan Iron & Steel, Baosteel, Shougang, and Tisco purchased a 15% stake in CBMM, which planned to increase its ferroniobium production capacity to 150,000 t/yr in 2014 (Camargo, 2012).

Mineração Taboca S.A. mined columbite at the Pitinga Mine in Presidente Figueiredo Municipality, Amazon State. Taboca produced a ferroniobiumtantalum alloy containing 45% niobium, 4.2% tantalum, and 25% iron that was sold for the production of niobium and tantalum oxide (Mineração Taboca S.A., 2013a, b).

Companhia Industrial Fluminense Mineração S.A. (owned by AMG Advanced Metallurgical Group N.V.) produced niobium and tantalum concentrate at the Volta Grande Mine near Nazareno, Mineras Gerais State. AMG planned to complete an updated NI 43–101 estimate of niobium and tantalum resources in 2013 (AMG Advanced Metallurgical Group N.V., 2013, p. 22, 25, 76).

Canada.—Niobium mine production, all from Quebec, was 4,819 t of contained Nb_2O_5 in 2012 compared with 4,551 t of contained Nb_2O_5 in 2011. No production of Ta_2O_5 was reported for 2011 or 2012 (Natural Resources Canada, 2013a, b).

Avalon Rare Metals Inc. (Toronto, Ontario) prospected for niobium and tantalum at its Nechalacho deposit at Thor Lake and tantalum at its Separation Rapids property. Avalon planned to complete a feasibility study for Nechalacho in 2013. At the Nechalacho deposit at Thor Lake, Avalon reported resources of 493 Mt at 0.31% Nb_2O_5 and 0.02% Ta_2O_5 (Avalon Rare Metals Inc., 2012). At Separation Rapids, Avalon reported petalite resources of 11.6 Mt at 0.007% Ta_2O_5 (Avalon Rare Metals Inc., 2013).

Commerce Resources Corp. (Vancouver, British Columbia) prospected for niobium and (or) tantalum at the Blue River (east of Quesnel, British Columbia), Eldor (south of Kuujjuaq, Quebec), and Carbo (northeast of Prince George, British Columbia) properties, which host carbonatite deposits. Commerce reported NI 43–101-compliant resources for the Blue River project, comprising Fir, Verity, and Upper Fir deposits, of 60.58 Mt containing 11,500 t of Ta_2O_5 and 91,500 t of Nb_2O_5 (Commerce Resources Corp., 2012, p. 1–9).

*Corrections posted May 30, 2014.

Critical Elements Corp. (Montreal, Quebec) developed the Rose tantalum property in the James Bay area of Quebec and explored Quebec Rare Earths project for tantalum and niobium. For the Rose property, Critical Elements reported 37.2 Mt of resource at 0.016% Ta_2O_5 (Critical Elements Corp., 2012, p. 4).

IAMGOLD (Toronto, Ontario) mined niobium contained in pyrochlore from the Saint-Honoré carbonatite deposit at the Niobec Mine, 15 km northwest of Chicoutimi, Quebec. Niobec mill production capacity was 4,500 t/yr of niobium in ferroniobium. The mill produced concentrate from which Niobec produced Nb_2O_5 that was then converted to standard grade (66% niobium) ferroniobium by aluminothermic reduction. In 2012, the Niobec Mine produced 4,707 t of niobium compared with 4,632 t of niobium in 2011. IAMGOLD reported reserves of 422.9 Mt at 0.42% Nb_2O_5 in addition to 720 Mt of resources at 0.40% Nb_2O_5 (IAMGOLD Corp., 2013, p. 26). IAMGOLD planned to increase production capacity at Niobec to 13,500 t of ferroniobium due to come onstream in phases starting in 2016 (Gibbons, 2012).

Geomega** Resources Inc. estimated 0.130% Nb_2O_5 contained in 251 Mt of resources at Montviel Core Zone in Quebec at a cutoff grade of 1% total rare-earth oxides. Geomega** planned to update its Montviel NI 43–101 report for 2013 (Geomega** Resources Inc., 2013, p. 3).

MDN Inc. (Montreal, Quebec) continued its development of the Crevier niobium project north of Lac Saint-Jean, Quebec. MDN developed flotation (to produce pyrochlore concentrate from ore) and leaching (to produce niobium and tantalum oxide from concentrate) processes and was seeking a strategic partner (MDN Inc., 2013, p. 14).

Niocan Inc. (Montreal, Quebec) explored for niobium minerals at its Oka property near Oka, Quebec. The company reported 13.85 Mt of resources at 0.66% Nb_2O_5 as of December 2009. Niocan planned to update its resource estimate (Niocan Inc., 2013, p. 2–3).

PhosCan Chemical Corp. (Toronto, Ontario) sought a process to recover niobium from ore processed for phosphate concentration from its Martison phosphate deposit near Hearst, Ontario. PhosCan achieved moderate niobium recovery and continued to develop the process (PhosCan Chemical Corp., 2013, p. 15).

Canada Rare Earth Inc. (formerly Rare Earth Metals) (Thunder Bay, Ontario) reported an 8.5 Mt inferred resource with 0.13% Nb_2O_5 at a cutoff grade of 0.6% total rare-earth oxides for the Clay-Howells deposit near Kapuskasing, Ontario. For the Two Tom deposit near Letitia Lake, Newfoundland and Labrador, the company reported a 41-Mt inferred resource at 0.26% Nb_2O_5 to a cutoff grade of 0.60% total rare-earth oxides (Rare Earth Metals Inc., 2011, p. 2, 64, 66; 2012, p. 73).

Quest Rare Minerals Ltd. (Montreal, Quebec) explored for niobium minerals, among other minerals, at Strange Lake rare-earth project on the Quebec-Labrador border. Quest reported resources of 492.5 Mt grading 0.16% Nb_2O_5 at Strange Lake. Quest's prefeasibility study discussed solvent extraction for the recovery of niobium at Strange Lake (Quest Rare Minerals Ltd., 2013, p. 5, 14).

Taseko Mines Ltd. (Vancouver, British Columbia) explored for niobium minerals at its Aley prospect in northern British Columbia. Taseko completed drilling to define ore reserves and planned to define metallurgical, process, and construction engineering requirements in 2014 (Taseko Mines Ltd., 2013, p. 4).

China.—The leading tantalum mining areas were at Yichun, Jiangxi Province, and Nanping, Fujian Province (Fetherston, 2004, p. 78–79). China consumed about 1,000 t/yr of tantalum, about two-thirds of which was imported (Ziguo and others, 2012).

Colombia.—Colombian police seized 17 t of illegally mined columbite-tantalite in the Amazon. Rebel groups in Colombia were thought to use illegally mined ore to finance their activities. No columbite-tantalite mining activities were sanctioned by the Government of Colombia in 2012 (Walsh, 2012).

Congo (Kinshasa).—Katanga, Kivu, Maniema, and Orientale Provinces in the eastern part of Congo (Kinshasa) host columbite-tantalite deposits (Fetherston, 2004, p. 71).

Noventa Ltd. (St. Helier, United Kingdom) planned to develop a tantalum mine in Katanga Province, where it holds exploration licenses and trading rights through its joint ownership in African Specialty Metals Sprl and Tantale et Niobium du Tanganika Sprl. (Noventa Ltd., 2012, p. 18).

Egypt.—Tantalum Egypt JSC [a joint venture of Gippsland Ltd. (Claremont, Australia) and the Government of Egypt] planned to mine tantalite from the Abu Dabbab and Nuweibi deposits. Gippsland reported 33.18 Mt reserves at 252 grams per metric ton (g/t) Ta_2O_5 at Abu Dabbab and 142.5 Mt resources at 176 g/t Ta_2O_5 at Abu Dabbab and Nuweibi. H.C. Stark Group GmbH (Goslar, Germany) committed to buy 600 t/yr contained Ta_2O_5 for 10 years. Gippsland planned to produce 3 Mt/yr run-of-mine ore from which it could produce 420 t of Ta_2O_5 (Gippsland Ltd., 2013, p. 8–9, 16).

Ethiopia.—The Ethiopian Mineral Development Share Co. (EMDSC), a state-owned enterprise, managed the Kenticha tantalum mine, which produced tantalum concentrate from a mine with a production capacity of 200 t/yr of concentrate grading 45% to 60% Ta_2O_5 and exported tantalum concentrate. EMDSC estimated proven reserves of 16.4 Mt at 0.015% Ta_2O_5 and inferred reserves of 100 Mt at 0.017% Ta_2O_5. EMDSC planned to vertically integrate its tantalum industry by installing a tantalum ore processing plant at its Kenticha Mine while tantalum mining was suspended in 2012. EMDSC was the leading tantalum ore producer with output of 125 to 230 t/yr supplemented by artisanal mining of 25 to 30 t/yr. The processing plant was expected to remove uranium, an ore constituent that had limited the shipment of raw tantalum ore and concentrate (Ethiopian Mineral Development Share Co., undated; Markram, 2012; Tekleberhan, 2012).

Finland.—Tertiary Minerals plc (Macclesfield, United Kingdom) was granted an exploration license for the Rosendal tantalum prospect (Kemiö Island). The deposit was a 1-Mt mineral resource grading 255 g/t Ta_2O_5 (Tertiary Minerals plc, 2012, p. 10).

Greenland.—Ram Resources Ltd. (Perth, Australia) explored the Motzfeldt area in southern Greenland. Ram reported 340

**Corrections posted September 3, 2014.

Mt of resources grading 4.6 kg/t Nb_2O_5 at its Aries (zirconium) Prospect (Ram Resources Ltd., 2012, p. 7–8).

Kenya.—Pacific Wildcat Resources Corp. (Vancouver, British Columbia, Canada) explored for niobium at Mrima Hill. The company reported a niobium inferred resource of 105.3 Mt at 0.654% Nb_2O_5 (Pacific Wildcat Resources Corp., 2011, p. 14, 18; 2012; p. 3–4).

Malawi.—Globe Metals & Mining Ltd. (West Perth, Australia), through its Kanyika project, planned to begin niobium mining in 2014, followed by ferroniobium production in 2015. Globe reported 68.3 Mt of resources for the project at 2.83 kg/t Nb_2O_5 and 135 g/t Ta_2O_5. Globe planned to complete a definitive feasibility study in 2012 (Globe Metals & Mining Ltd., 2013).

Mozambique.—Highland African Mining Co. Ltd. [a subsidiary of Noventa Ltd. (St. Helier, United Kingdom)], operated the Marropino Mine, held concessions for the Morrua and Mutala deposits, and held exploration licenses for adjacent areas. Noventa reported indicated resources of 7.40 Mt at 223 g/t Ta_2O_5 at Marropinno and 4.65 Mt at 510 g/t Ta_2O_5 at Morrua. Noventa planned to complete a processing plant upgrade and ramp up production at Marropinno, and continue development of the Morrua and Mutala concessions (Noventa Ltd., 2012, p. 2).

Namibia.—Procomex Namibia Pty. Ltd. (Uis) planned to reopen the Uis Mine, which formerly produced tin and tantalite. Procomex planned to start tantalum ore production after construction of a new processing plant, rehabilitation of the water infrastructure, and modernization of electrical connections by NamPower, Namibia's national electrical power utility (Hartman, 2012).

Outlook

Niobium.—As much as 90% of global niobium use was as an additive in steelmaking, mostly in the manufacture of microalloyed steels (Roskill Information Services Ltd., 2009, p. 1–3). The production of HSLA steel was the leading use for niobium. The trend for niobium consumption, domestically and globally, was expected to continue to closely follow that of niobium-containing-steel production. (Additional information about the steel industry can be found in the Iron and Steel chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.) Consumption of niobium, however, does not coincide with trends in overall steel production, as only 10% of steel products contain niobium. The leading nonsteel use of niobium was in superalloys for, among other applications, aircraft engines.

The long-term growth of niobium use was interrupted by the economic downturn of 2008–09. Niobium is mainly used in HSLA steels consumed by automobile, construction, and pipeline industries. Greater demand for natural gas was expected to result in increased demand for pipeline steel. The sharp fall in demand for automobiles and in construction that started in 2008 was expected to decrease demand for niobium-containing steel. Recovery of these markets was expected to revive demand for niobium. It was reported that the global unit consumption of niobium per ton of steel produced was 55 to 60 g/t, while that of highly economically developed countries was 100 g/t and that of China was 40 g/t, suggesting significant potential for niobium consumption growth as the Chinese economy develops (Roskill Information Services Ltd., 2009, p. 124–125).

Tantalum.—Tantalum supply comprises artisanal and conventional mining, slags and synthetic concentrates, recycling, and stocks. World primary production was expected to increase from about 1,100 t of tantalum in 2011 to about 1,600 t of tantalum in 2016. Conventional mining accounted for about one-half of supply in 2011. If conventional mining accounts for all of the expected growth, an additional 500 t of tantalum in mine expansions and new projects would be needed to account for that amount of material. It has been estimated that current producers collectively will probably increase production by 600 t of tantalum, and that projects are currently being planned collectively would increase production by more than 1,300 t of tantalum. Thus, expansions at existing operations and projects in the pipeline were more than adequate to meet anticipated growth. Processing capacity would also need to increase to convert that ore and concentrate into intermediate and final chemical and metal products (Roskill Information Services Ltd., 2012, p. 2, 6, 21–23, 31–33).

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TABLE 1
SALIENT NIOBIUM STATISTICS[1]

		2008	2009	2010	2011	2012
United States:						
Exports, Nb content[2]	metric tons	781	195	281	363	385
Imports for consumption:						
Mineral concentrates, Nb content	do.	134	41	5	23	32
Niobium metal, gross weight[3]	do.	1,130	699	1,380	1,460	1,440
Niobium oxide, Nb content[e]	do.	852	742	824	1,120	1,220
Ferroniobium, Nb content[e]	do.	7,120	2,920	6,280	6,910	7,430
Reported consumption, Nb content						
Raw materials	do.	W	W	W	W	W
Ferroniobium and nickel niobium	do.	5,380	4,350	5,590	9,060 r	7,670 e
Apparent consumption, Nb content	do.	8,450	4,210	8,210	9,160	9,730
Value:[4]						
Niobium ores and concentrates (gross weight)	dollars per kilogram	26.70	59.86	19.84	39.34	23.54
Niobium oxide (gross weight)	do.	25.65	27.30	30.32	37.69	44.43
Ferroniobium (gross weight)	do.	21.29	23.59	24.01	26.43	27.63
World, production of niobium-tantalum concentrates, Nb content	metric tons	106,000 r	67,100 r	49,000 r	50,100 r, e	50,100 e

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits, except values.
[2]Includes natural and synthetic niobium ore and concentrates, niobium oxide, niobium ferroalloy, and unwrought niobium metal and alloys.
[3]Includes niobium and articles made of niobium.
[4]Weighted average value of imported plus exported materials.

TABLE 2
SALIENT TANTALUM STATISTICS[1]

		2008	2009	2010	2011	2012
United States:						
Exports:						
Tantalum ores and concentrates,[2] Ta content	metric tons	96	94	58	65	124
Tantalum metal, gross weight	do.	390	138	246	443	341
Tantalum and tantalum alloy powder, gross weight	do.	176	94	134	140	111
Imports for consumption:						
Mineral ores and concentrates, Ta content	do.	357	109	9	60	82
Tantalum metal and tantalum-bearing alloys,[3] gross weight	do.	934	689	1,590	1,800	932
Reported consumption, raw materials Ta content	do.	W	W	W	W	W
Apparent consumption, Ta content	do.	629	473	1,160	1,210	437
Price, tantalite,[4] Ta_2O_5 content	dollars per kilogram	96	89	120	275	239
Value,[5] tantalum ores and concentrates, gross weight	do.	49	30	32	46	45
World, production of niobium-tantalum concentrates, Ta content	metric tons	2,230 r	1,060 r	664 r	613 r, e	727 e

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Includes natural and synthetic tantalum ore and concentrates.
[3]Includes unwrought powders, unwrought alloys and metals, waste and scrap, and wrought alloys and metal.
[4]Average annual price per Ta_2O_5 content as reported in Ryan's Notes.
[5]Weighted average value of imported plus exported materials.

TABLE 3
REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIOBIUM AND NICKEL NIOBIUM, AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES[1]

(Metric tons of niobium and tantalum content)

	2011	2012
End use:		
Steel:		
Carbon	1,630	1,570
Stainless and heat-resisting	718 r	811
Full alloy	(2) r	(2)
High-strength low-alloy	815 r	784
Electric	(2)	(2)
Tool	(2) r	(2)
Unspecified	2,880 r	2,870
Total	6,040 r	6,030
Superalloys	3,000 r	1,620
Alloys (excluding steels and superalloys)	22 r	18
Grand total	9,060 r	7,670 e
Stocks, December 31:		
Consumer	402 r	388
Producer[3]	W	W
Total	402 r	388
National Defense Stockpile, total uncommitted inventory by material:		
Niobium metal ingots	10.0	10.0
Tantalum carbide powder	1.72	1.71

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Included with "Steel, unspecified."
[3]Ferroniobium only.

TABLE 4

U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS[1]

HTS code[2]	Class	2011 gross weight (kilograms)	2011 Value (thousands)	2012 gross weight (kilograms)	2012 Value (thousands)	Principal destinations and sources in 2012 (gross weight in kilograms and values in thousand dollars)
	Exports:					
	Niobium:					
2615.90.6030	Ores and concentrates	12,300	$129	31,500	$239	Germany 25,000, $179; United Kingdom 1,690, $12; Japan 1,470, $10; India 1,120, $8; France 743, $5; China 589, $4; Italy 360, $22.
7202.93.0000	Ferroniobium	519,000	5,640	512,000	5,630	Canada 403,000; $4,430; Mexico 55,400, $611; Chile 27,300, $300; United Kingdom 16,200, $178; Peru 7,130, $81; Belgium 2,480, $27; Colombia 136, $5.
	Tantalum:					
2615.90.3000	Synthetic concentrates	20,400	1,610	209,000	2,840	China 201,000, $2,800; Mexico 5,440, $19; Trinidad and Tobago 1,500, $12; Spain 369, $3; Argentina 287, $3; Germany 8, $3.
2615.90.6060	Ores and concentrates	186,000	1,680	202,000	7,830	Brazil 115,000, $1,100; Germany 32,700, $3,360; Thailand 25,200, $2,600; Austria 12,200, $268; Hong Kong 11,700, $370; Taiwan 2,630, $58; United Kingdom 1,430, $32; Netherlands 1,430, $32.
8103.20.0030	Unwrought, powders	140,000	66,500	111,000	45,900	Mexico 48,900, $21,700; Sweden 19,200, $6,400; El Salvador 14,400, $2,690; Germany 12,900, $8,340.
8103.20.0090	Unwrought, alloys and metal	58,800	18,000	25,200	9,000	Germany (all).
8103.30.0000	Waste and scrap	303,000	30,400	235,000	31,000	United Kingdom 63,300, $5,710; China 38,400, $4,140; Kazakhstan 32,600, $6,530; Germany 26,200, $6,280; Austria 18,500, $3,300; Netherlands 16,800, $1,470; Hong Kong 11,100, $1,260; Malaysia 8,110, $716; France 6,650, $582; Japan 5,950, $527.
8103.90.0000	Wrought	81,800	47,800	81,200	59,000	Germany 36,100, $22,400; Mexico 14,300, $8,620; France 9,510, $9,340; Japan 8,260, $7,780.
	Total	XX	181,000	XX	161,000	
	Imports for consumption:					
	Niobium:					
2615.90.6030	Ores and concentrates	9,090	710	11,000	761	China 9,480, $710; France 1,030, $2; Germany 500, $48.
2825.90.1500	Oxide	1,610,000	60,600	1,740,000	77,400	Brazil 1,530,000, $64,100; China 136,000, $8,260; Russia 38,500, $2,680; Germany 34,100, $2,080; Netherlands 5,000, $261; Hong Kong 68, $4; Liechtenstein 12, $17.
	Ferroniobium:					
7202.93.4000	Silicon < 0.4%	1,020,000	34,600	83,000	37,000	Brazil 711,000, $28,400; United Kingdom 104,000, $7,260; Germany 15,200, $1,370.
7202.93.8000	Other	9,610,000	254,000	1,060,000	287,000	Brazil 8,860,000, $241,000; Canada 1,730,000, $46,200; United Kingdom 907, $75.
	Total	10,630,000	289,000	11,400,000	324,000	
8112.92.4000	Unwrought, powders[3]	1,460,000	74,100	1,440,000	84,400	Brazil 1,280,000, $70,500; Germany 91,900, $6,770; Estonia 45,700, $5,470; China 12,300, $1,030; Canada 8,430, $290; Thailand 682, $200; Japan 638, $54; Spain 408, $73.
	Tantalum:					
2615.90.3000	Synthetic concentrates	10,700	56	--	--	
2615.90.6060	Ores and concentrates	179,000	15,200	261,000	13,000	Ethiopia 69,000, $4,510; Rwanda 63,900, $3,520; Indonesia 37,600, $1,760; Canada 35,100, $481; Bolivia 23,400, $423; Tanzania 13,200, $962; South Africa 9,060, $620; Colombia 4,160, $221; China 3,740, $283; Nigeria 2,010, $182; United Kingdom 6, $7.
8103.20.0030	Unwrought powders	101,000	31,400	138,000	57,400	Thailand 61,000, $28,300; Germany 43,100, $21,100; China 10,200, $3,700; Japan 8,360, $2,950; Czech Republic 7,490, $923; Singapore 7,000, $501; Mexico 23, $19; Canada 8, $7.
8103.20.0090	Unwrought, alloys and metal	204,000	57,800	205,000	78,000	Kazakhstan 116,000, $42,400; China 38,600, $16,200; Germany 20,900, $8,280; Estonia 17,700, $5,660; United Kingdom 10,300, $5,150; Singapore 1,580, $178; Sweden 90, $23.
8103.30.0000	Waste and scrap	1,370,000	60,900	519,000	99,800	Indonesia 143,000, $9,820; China 113,000, $25,300; Japan 56,200, $6,190; Estonia 43,000, $21,000; Germany 41,400, $13,700; Mexico 19,900, $1,540.
8103.90.0000	Wrought	124,000	53,600	70,200	36,700	China 33,800, $21,600; Kazakhstan 14,300, $7,810; France 4,940, $1,530; El Salvador 3,320, $409.
	Total	XX	643,000	XX	772,000	

TABLE 4

U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS[1]

XX Not applicable. -- Zero.

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

[2]Harmonized Tariff Schedule of the United States.

[3]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 5

U.S IMPORTS FOR CONSUMPTION OF TANTALUM ORES AND CONCENTRATES, BY COUNTRY[1]

	2011		2012	
Country	gross weight (kilograms)	Value (thousands)	gross weight (kilograms)	Value (thousands)
Australia	111,000	$11,200	--	--
Bolivia	1,297	45	23,400	$423
Brazil	20,000	2,740	--	--
Canada	20,200	325	35,100	481
China	773	21	3,740	283
Colombia	--	--	4,160	221
Ethiopia	--	--	69,000	4,510
Indonesia	--	--	37,600	1,760
Kakahstan	65	18	--	--
Mozambique	26,000	796	--	--
Nigeria	--	--	2,005	182
Portugal	3	3	--	--
Rwanda	--	--	63,900	3,520
South Africa	--	--	9,060	620
Tanzania	--	--	13,200	962
United Kingdom	--	--	6	7
Total	179,000	15,100	261,000	13,000

-- Zero.

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

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

TABLE 6

NIOBIUM AND TANTALUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Country[5]	Gross weight[3]					Niobium content[4]					Tantalum content[4]				
	2008	2009	2010	2011[e]	2012[e]	2008	2009	2010	2011[e]	2012[e]	2008	2009	2010	2011[e]	2012[e]
Australia, columbite-tantalite[6]	2,060 [e]	318	--	--	--	--	--	--	--	--	557	86 [r]	--	--	--
Brazil:															
Nb minerals[e, 7, 8]	12,000,000 [r]	7,000,000 [r]	5,000,000 [r]	5,000,000 [r]	5,000,000	101,022 [r, 9]	62,159 [r, 9]	44,270 [r, 9]	45,198 [r, 9]	45,000	--	--	--	--	--
Ta minerals[6, 10]	1,200 [r, e]	1,100 [r, e]	880 [r, e]	680 [r]	680	--	--	--	--	--	245 [r]	218 [r]	176 [r]	136 [r, 9]	140
Burundi	84 [r]	44 [r]	67 [r]	166 [r, 9]	170	16 [r]	9 [r]	13	32 [r, 9]	33	16 [r]	9 [r]	13 [r]	32 [r, 9]	33
Canada:															
Nb minerals[8]	1,801,000 [r]	1,773,000 [r]	1,792,000 [r]	2,087,000 [r, 9]	2,155,000 [9]	4,383	4,330	4,419	4,632 [9]	4,707 [p, 9]	--	--	--	--	--
Ta minerals[e, 6, 10]	150 [9]	110 [9]	--	75 [r]	150	6 [r]	5 [r]	--	2 [r]	5	49 [r]	30 [r]	--	25 [r]	50
China[e]	NA	NA	NA	NA	NA	210	21	22	17	14	737	74	70	61	57
Congo (Kinshasa):															
Columbite-tantalite[e, 11]	527 [9]	468 [9]	397 [9]	380 [r]	380	120 [r]	110	90 [r]	90 [r]	90	140	130	110	100 [r]	100
Nb minerals	119	80 [r, e]	--	-- [9]	-- [9]	59 [e]	40 [r, e]	--	-- [9]	-- [9]	--	--	--	--	--
Ethiopia, tantalite	224 [r]	398 [r]	252 [r]	285 [r]	290	16 [r]	28 [r]	22 [r]	25 [r]	25	78 [r]	99 [r]	82 [r, 7]	95 [r, 7]	95
Mozambique[e]	396 [r, 9]	405 [9]	55 [r, 9]	139 [r, 9]	140	28	29	4 [r]	10 [r]	10	110	113	15 [r]	39 [r]	39
Nigeria, columbite-tantalite[e]	335 [r]	331 [r]	281 [r]	311 [r]	310	23 [r]	23 [r]	20 [r]	22 [r]	22	69 [r]	68 [r]	58 [r]	64 [r]	63
Rwanda	922 [r]	952 [r]	560 [r]	250 [r, 9]	600	300 [r]	310 [r]	180 [r]	80 [r]	190	230 [r]	230 [r]	140 [r]	61 [r]	150
Somalia[e, 12]	11	7	--	--	--	2	2	--	--	--	3	2	--	--	--
Uganda[e]	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)
Total	13,800,000 [r]	8,780,000 [r]	6,790,000 [r]	7,090,000 [r]	7,160,000	106,000 [r]	67,100 [r]	49,000 [r]	50,100 [r]	50,100	2,230 [r]	1,060 [r]	664 [r]	613 [r]	727

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. -- Zero.

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

[2]Excludes production of columbium and tantalum contained in tin ores and slags. Table includes data available through November 15, 2013.

[3]Gross weight is weight of concentrate before metal is extracted.

[4]Content is weight of metal produced. Nb_2O_5 is 69.904% niobium; Ta_2O_5 is 81.897% tantalum.

[5]In addition to the countries listed, Bolivia, French Guiana, Kazakhstan, and Russia also produce, or are thought to produce, niobium and tantalum mineral concentrates, but available information is inadequate to make reliable e output levels.

[6]Tantalum production reported in Ta_2O_5 converted to tantalum content. Gross weight is concentrate assumed to be one-third Ta_2O_5.

[7]Niobium concentrate production reported in Nb_2O_5 content converted to niobium content. Gross weight is concentrate assumed to be one-third Nb_2O_5.

[8]Includes columbite and pyrochlore.

[9]Reported figure.

[10]Includes djalmaite and tantalite.

[11]Reported data includes the North and South Kivu Provinces.

[12]From August 2008 to April 2009, 18 metric tons of columbite-tantalite were reportedly produced in Somalia. It is unclear if production continued after early April 2009.

[13]Less than ½ unit.

TABLE 7

FERRONIOBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY[1]

(Metric tons, Nb content)

Country[2]	2008	2009	2010	2011	2012[e]
Brazil	53,839 r	34,746 r	52,588 r	53,691 r	54,000
Canada	4,383 r	4,330 r	4,343 r	4,632 r	4,707 [3]
Russia[e]	53 r	52 r	53 r	53 r	53
United States	NA	NA	NA	NA	NA
Total	58,300 r	39,100 r	57,000 r	58,400 r	58,800

[e]Estimated; estimated data are rounded to no more than three significant digits; may not add to totals shown.
[r]Revised. NA Not available.
[1]Table includes data available through July 23, 2013.
[2]In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but production information is inadequate for the formulation of estimates of output levels.
[3]Reported figure.

TABLE 7

FERRONIOBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY[1]

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Brazil	53,839 r	34,746 r	52,588 r	53,691 r	54,000
Canada	4,383 r	4,330 r	4,343 r	4,632 r	4,707 [3]
Russia[e]	53 r	52 r	53 r	53 r	53
United States	NA	NA	NA	NA	NA
Total	58,300 r	39,100 r	57,000 r	58,400 r	58,800

[e]Estimated; estimated data are rounded to no more than three significant digits; may not add to totals shown.
[r]Revised. NA Not available.
[1]Table includes data available through July 23, 2013.
[2]In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but production information is inadequate for the formulation of estimates of output levels.
[3]Reported figure.