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2014 Minerals Yearbook

NIOBIUM (COLUMBIUM) AND TANTALUM [ADVANCE RELEASE]

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Niobium (Columbium) and Tantalum

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In 2014, U.S. niobium apparent consumption (measured in contained niobium) was 10,000 metric tons (t), 23% more than that of 2013; U.S. tantalum apparent consumption (measured in contained tantalum) was 479 t, 84% more than that of 2013. No domestic mine production of niobium or tantalum ore was reported. Compared with that of the previous year, niobium content of world production of niobium minerals decreased slightly, whereas tantalum content of world production was about the same. U.S. imports of tantalum materials (based on gross quantity of imports) increased by 19%, and U.S. exports of tantalum materials (based on gross quantity of exports) increased slightly. U.S. imports of niobium materials (based on gross quantity of imports) increased by 29%, and U.S. exports of niobium materials (based on gross quantity of exports) increased by 140%. 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 Burundi (tantalum), Congo (Kinshasa) (tantalum), Mozambique (tantalum), and Rwanda (tantalum) in the Eastern Hemisphere. World niobium and tantalum reserves are adequate to meet anticipated world demand. Materials for recycling and stocks are the only domestic supply sources of niobium and tantalum.

Traded tantalum materials included chemicals, metal, potassium heptafluorotantalate (commercially known as K-salt), residue, scrap, slag, and tantalum ore and concentrate. K-salt and tantalum oxide do not have unique Harmonized Tariff Schedule of the United States (HTS) codes. As a result, a potentially large part of tantalum material trade is undocumented. The absence of unique HTS codes for these tantalum materials eliminates movement transparency for those materials and thereby may facilitate covert movement of illicit materials.

Legislation and Government Programs

The Defense Logistics Agency Strategic Materials (DLA Strategic Materials), U.S. Department of Defense, did not designate niobium or tantalum materials for disposal under its fiscal year 2015 Annual Materials Plan (Defense Logistics Agency Strategic Materials, 2014a); however, the DLA Strategic Materials designated a ceiling quantity of 104.5 t of ferroniobium for acquisition and requested an additional 187,000 pounds of tantalum (Defense Logistics Agency Strategic Materials, 2014b; Under Secretary of Defense for Acquisition, Technology and Logistics, 2015, p. 8).

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 if any of those minerals originated in Congo (Kinshasa) or an adjoining country.

Production

The leading marketable niobium materials are ferroniobium and niobium metal, ore, and oxide. The leading marketable tantalum materials are tantalum metal (unwrought and wrought alloys, metal, and powder), ore, and scrap. In 2014, neither niobium nor tantalum domestic mine production was reported.

NioCorp Developments Ltd. reported 180 million metric tons (Mt) of resources, of which 80.5 Mt were indicated resources at 0.71% niobium pentoxide (Nb_2O_5) and 99.6 Mt were inferred resources at 0.56% 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., 2015, p. 5).

Global Advanced Metals Pty. Ltd. (GAM) (Australia), a vertically integrated tantalum producer, produced capacitor-grade tantalum metal powder and metallurgical products of tantalum, niobium, and their alloys at its Boyertown, PA, plant (Global Advanced Metals Pty. Ltd., undated). GAM owned tantalum mines and processing facilities in Australia, refined tantalum in the United States, and conducted advanced powder processing in Japan. GAM produced tantalum powder and wire for capacitor anodes, tantalum materials for tantalum target production, and tantalum mill products. GAM primarily supplied the capacitor market segment; however, it also contributed to the superalloy market segment supply (Zogbi, 2012, p. 22, 56, 63, 65).

Consumption

Domestic consumption data for niobium and tantalum 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 and tantalum materials, one consumer responded to the "Columbium (Niobium) and Tantalum" canvass, about 70 responded to the "Consolidated Consumers" canvass, and one responded to the "Specialty Ferroalloys" canvass. The steel industry accounted for about 80% of niobium and tantalum reported consumption; other uses, predominantly the superalloy industry, accounted for the remaining 20% (table 3).

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 electronics industry was the leading tantalum consumer, accounting for more than one-half of tantalum use, and electronic capacitors were the leading electronic use. Tantalum provides high dielectric constant and oxide layer stability to tantalum capacitors, resulting 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 increases the refractive index of the glass used in camera lenses, tantalum carbide increases the toughness of cemented carbide cutting tools, and tantalum nitride contributes to the inertness of diffusion barriers in microelectronic circuits (Burt and Schwela, 2013, p. 4–13).

ATI Wah Chang, 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.

The global distribution of tantalum into end-use markets (in 2011, the most recent year for which estimates were reported) was estimated to have been ingot for sputtering (180 t), mill products and other (350 t), powder for alloys (240 t), powder for capacitors (860 t), powder for carbide (180 t), and tantalum chemicals (410 t). Capacitors are passive electronic components used in virtually all electronic circuits. Tantalum capacitor material use has been steady despite increased use of tantalum capacitors because technological improvements have permitted the same capacitive effect to be attained with progressively smaller amounts of material. As long as that trend continues, the amount of tantalum used in electronic capacitors will remain constant. Tantalum targets are used for sputtering thin films in semiconductor applications (microelectronic circuits) to make barriers that prevent the diffusion of copper into silicon substrates (Zogbi, 2012, p. 42–47, 51, 64, 66, 72).

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 2014, the annual average price of tantalite ore per pound of contained tantalum pentoxide (Ta_2O_5) was $100.287, a 15% decrease compared with that of 2013. The tantalite ore price was $87.500 per pound of contained tantalum oxide in December, down 25% from $116.500 in January.

Tantalum ore and concentrate price is described as opaque because there is no open market and the only source of price data is spot price in trade journals. Industrial tantalum ore and concentrate producers make long-term contracts that specify confidential prices with processors, so the spot price does not apply (Burt and Schwela, 2013, p. 4–13).

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 2014, the values of foreign trade of these niobium and tantalum materials were $227 million for exports (13% more than that of 2013) and $780 million for imports (13% more than that of 2013) (table 4).

In 2014, the United States exported 1,110 t of niobium contained in niobium materials (154% more than that of 2013) and imported 11,100 t of niobium contained in niobium materials (30% more than that of 2013) (table 1). The United States exported 754 t of tantalum contained in tantalum materials (11% less than that of 2013) and imported 1,230 t of tantalum contained in tantalum materials (12% more than that of 2013) (table 2).

World Industry Structure

Brazil and Canada were the leading producers of niobium mineral concentrates; Congo (Kinshasa) 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) and Anglo American Brazil Ltd. (a subsidiary of Anglo American plc) in Brazil and IAMGOLD Corp. at its Niobec Mine in Canada. The leading tantalum ore and concentrate producers were artisanal mining operations in Congo (Kinshasa) and Rwanda and vertically integrated mining operations of AVX Corp. and Kemet Corp. in Congo (Kinshasa), which were expected to substantially increase their production (Zogbi, 2012, p. 91).

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 about 700 t of contained tantalum in 2013, the most recent year for which data were available. Niobium primary production from niobium concentrates and other concentrates containing more than 2% Nb_2O_5 was estimated to have been about 65,000 t of contained niobium in 2013 (Tantalum-Niobium International Study Center, 2014).

Niobium

The world steel industry accounted for approximately 90% of world niobium consumption. Niobium is not used in all HSLA and stainless steels; however, in those grades in which it is used, HSLA steels contain about 0.05% niobium by weight and stainless steels contain 0.04% to 0.08%. HSLA steels were the leading consumer of ferroniobium; structural steel accounted for 45% of world ferroniobium consumption; automotive steel, 23%; line pipe steel, 16%; and stainless steel, 6%. Leading world ferroniobium producers were CBMM (Brazil), Mineração

Catalão de Goias (Brazil), and IAMGOLD Corp. (Canada), which collectively accounted for most of world niobium production and marketed their production as ferroniobium. World ferroniobium shipments, measured in contained niobium, were 53,500 t in 2012, an increase from 52,200 t in 2011 (Roskill Information Services Ltd., 2013, p. 110, 115, 116, 125, 127, 129, 134).

Tantalum

There are variations in reporting the distribution of world tantalum supply sources, but industry analysts' estimates of world supply give a range of mining (51%–74%), recycling (18%–26%), and tin slags and synthetic concentrates (8%–12%) (Roskill Information Services Ltd., 2012, p. 17). Alternatively, tantalum supply (in 2011) was estimated to have come from mining (51%), recycling (26%), tin (12%), and inventories (11%) (Zogbi, 2012, p. 32). In 2013, tantalum from tin slags was thought to be about 25% to 33% of processor output. Recycling was thought to have supplied 20% to 33% of processor output (Burt and Schwela, 2013, p. 4–13).

Likely world tantalum resources were reported to have been distributed among (listed in descending order of resources) South America (41%), Australia (21%), China and Southeast Asia (10%), Russia and the Middle East (10%), Central Africa (9%), other Africa (7%), and North America (2%). In 2014, Rwanda was the leading mine producer of tantalum minerals followed by Congo (Kinshasa) and Brazil. The sources of tantalum ore production are artisanal and industrial tantalum mines; tin mines; and low-grade slag stockpiles, which supply processors with concentrates. Recycling supplies processors with scrap metal. Tantalum ore and concentrate was supplied by artisanal and industrial mines; tin slag, by tin smelters. Historically (before the late 1980s), most tantalum was produced from tin slags; since then, tantalum mines have dominated supply. As tantalum consumption increased in the 1980s, two integrated processors emerged—Cabot Corp. in the United States and H.C. Starck GmbH in Germany. Both companies spawned subsidiary tantalum processors in other countries, taking over 90% of the world market in the 1990s. Australia was the leading tantalum ore producer until 2008 when the Greenbushes and Wodgina Mines were put on care-and-maintenance status, leaving Brazil as the leading tantalum ore producer. Ningxia Non-Ferrous Metals Smeltery and other Chinese businesses entered the tantalum processing industry. In 2013, there were also significant tantalum integrated processors in Estonia and Kazakhstan (Burt and Schwela, 2013, p. 4–13).

World Review

Australia.—Australia reported that, as of December 31, 2012, 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 of contained niobium and 29,000 t of contained tantalum, and accessible economic demonstrated resources were 205,000 t of contained niobium and 60,000 t of contained tantalum (McKay and others, 2014, p. 6).

Pilbara Minerals Ltd. and Nagrom Mining Pty Ltd. constituted the Tabba Tabba Joint Venture (JV) that planned to mine tantalite about 75 kilometers (km) east of Port Hedland, Western Australia. The mine was planned to start production in 2015. Global Advanced Metals had an offtake agreement. Tabba Tabba JV had combined resources of 212,900 t of tantalite ore containing 0.04% to 0.55% Ta_2O_5, and an average grade of 0.122% Ta_2O_5 (equivalent to about 572,200 lb of Ta_2O_5). Resources were 30,100 t at 0.161% Ta_2O_5 measured, 124,400 t at 0.126% Ta_2O_5 indicated, and 58,400 t at 0.0925% Ta_2O_5 inferred. Reserves were 133,000 t at 0.129% Ta_2O_5, of which there was 32,000 t at 0.142% Ta_2O_5 proved and 101,000 t at 0.125% Ta_2O_5 probable (Pilbara Minerals Ltd., 2014). Pilbara Minerals also acquired the Pilgangoora tantalum-lithium project from GAM (Pilbara Minerals Ltd., 2015a). Pilgangoora is located just 55 km south of Pilbara's Tabba Tabba Tantalum Project, with the potential to provide long-term mine life extension to Tabba Tabba operations. Pilbara Minerals reported indicated and inferred resources of 21.7 Mt at 0.0224% Ta_2O_5 containing 10.7 million pounds of Ta_2O_5 (Pilbara Minerals Ltd., 2015b).

Brazil.—Niobium mine production in Brazil was 73,668 t of contained Nb_2O_5 from reserves of 10.7 Mt of Nb_2O_5 in 2013. Final products were 73,668 t of Nb_2O_5 contained in concentrate, 46,555 t of niobium contained in ferroniobium, and 6,200 t of Nb_2O_5 (Pereira, 2014). Brazilian tantalum mine production was 185 t of tantalum contained in concentrate from reserves of 36,190 t of tantalum in 2013 (Pontes, 2014).

Anglo American Brazil Ltd. (a subsidiary of Anglo American plc) mined pyrochlore from a carbonatite deposit. The Catalao Mine comprised three open pit mines and a processing facility near the city of Catalao, Goias State. Anglo reported production of 4,700 t of niobium contained in ore in 2014 compared with 4,500 t in 2013. JORC-compliant (operation plus project) reserves in 2014 were 47.4 Mt at 0.80% Nb_2O_5, with resources of 53.6 Mt at 1.0% Nb_2O_5 (Anglo American plc, 2015, p. 56, 188). Anglo operated the Boa Vista and Boa Vista Fresh Rock Mines.

CBMM mined niobium ore from the Barreiro carbonatite complex near Araxa, Minas Gerais State, and beneficiated the ore at the mine site by selectively extracting the pyrochlore minerals from which niobium oxide was produced. CBMM produced ferroniobium, nickel-niobium, niobium metal, niobium oxide, and high-purity ferroniobium, and had production capacity of 90,000 t ferroniobium equivalent. CBMM planned to increase production capacity to 150,000 t in 2016 (Companhia Brasileira de Metalurgia e Mineração, undated).

Mineração Taboca S.A. mined columbite at the Pitinga Mine in Presidente Figueiredo Municipality, Amazon State. Taboca produced a ferroniobium-tantalum alloy containing 45.00% niobium, 4.20% tantalum, and 25.00% iron that was sold for the production of niobium and tantalum oxide (Mineração Taboca S.A., 2013).

MBAC Fertilizer Corp. (2014, p. 11–12) reported Araxa resources of 28.28 Mt at 0.73% Nb_2O_5. MBAC produced high-purity niobium and tantalum oxides at the bench scale from the Nb_2O_5 concentrate stream produced in its pilot plant. MBAC planned to start mine production in 2015 followed by full-scale production in 2016. At full production, MBAC planned to produce 742 metric tons per year (t/yr) of Nb_2O_5 as a byproduct, increasing to 1,830 t/yr in 2023. Mine life was expected to be 40 years.

Companhia Industrial Fluminense Mineracao S.A. (CIF) (owned by AMG Advanced Metallurgical Group N.V.) produced niobium and tantalum concentrate at the Mibra (Volta Grande) Mine near Nazareno, Minas Gerais State. AMG completed an NI 43–101 technical report in 2013. AMG reported (measured plus indicated plus inferred) resources of 8.88 Mt at 0.0310% Ta and 0.00588% Nb. AMG estimated the mine life at 20 years (AMG Advanced Metallurgical Group N.V., 2013; 2015, p. 2, 16, 109).

Canada.—Canada reported niobium mine production of 5,480 t of contained Nb_2O_5 in 2014 compared with 4,920 t of contained Nb_2O_5 in 2013. No production to Ta_2O_5 was reported for 2014 or 2013. Niobium ore was mined in Quebec (Natural Resources Canada, undated a, b).

IAMGOLD (Toronto, Ontario) mined niobium contained in pyrochlore from the Saint-Honoré carbonatite deposit at Niobec Inc.'s Niobec Mine 15 km northwest of Chicoutimi, Quebec. Niobec mill production capacity was 4,500 t/yr of niobium. 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 2014, the Niobec Mine mined 2,355 t of ore, milled 2,374 t of ore at 0.58% Nb_2O_5, and produced 5,600 t of ferroniobium (FeNb) compared with 2,831 t mined, 2,348 t milled at 0.56% Nb_2O_5, and 5,300 t of FeNb produced in 2013. (IAMGOLD Corp., 2015, p. 15–16). IAMGOLD sought and found a buyer for Niobec in 2014 and expected to close the sale in 2015 for $530 million. The sale of Niobec consisted of an underground niobium mine; the associated processing facilities located in Saint-Honoré-de-Chicoutimi in the Saguenay-Lac-Saint-Jean region, Quebec; and an adjacent rare-earth element deposit. Magris Resources Inc. planned to purchase Niobec Inc.

China.—Tantalum was mined at Guangxi Limu Mining Co., Ltd.; Inner Mongolia Baotou; Jiangxi Yinchun; and Xinjiang Keketuohai. Ore and concentrate from those operations supported the tantalum processing industry, which consisted of Conghua Tantalum & Niobium Smeltery Ltd., Guangxi Limu Nonferrous Metal Co., Hunan Zhuzhou Hard Alloy Factory, Jiangxi Jiulong Nonferrous Metal Smeltery Ltd., and Ningxia Orient Tantalum Industry Co., Ltd., among others. Huidian Research (2013, p. 16–17, 20–21, 24–25, 34–41, 44) reported that more than 92 mines produced tantalum ore from 540,000 t of Ta_2O_5 reserves. More than 70% of tantalum reserves were in Guangdong and Jiangxi Provinces and the Nei Mongol Autonomous Region. The leading tantalum mines were Jiangxi Yichun Tantalum Mine, Fujian Nanping Tantalum Mine, Guangxi Limu Mine, Hunan Chaling Tantalum Mine, and Sinkiang Koktokay Mine. These mines and imported tantalum materials supplied China's major tantalum-processing industries, which were Ningxia Orient Tantalum Industry Co. Ltd.; Sinkiang Nonferrous Metals Industry Group Rare Metals Co., Ltd.; Conghua Tantalum & Niobium Smeltery; Jiujiang Tanbre Co., Ltd. (formerly named Jiujiang Tanbre's Smeltery); and Changsha South Tantalum Niobium Co., Ltd. Huidian Research (2013) forecast 12% growth per year for China's tantalum industry through 2017 to 2022 based on China's projected economic transformation, which was expected to increase domestic tantalum demand driven by urbanization and industrial transformation to high-technology products that were tantalum-use intensive.

Jiangxi Nonferrous Geology Survey planned to develop a niobium-tantalum deposit in Jiangxi Province. The deposit, which was discovered 10 years ago, was reported to have proven reserves of 30,000 t of tantalum and 40,000 t of niobium (Argus Minor Metals, 2015, p. 11).

Congo (Kinshasa).—Katanga, Maniema, North Kivu, Orientale, and South Kivu Provinces in the eastern part of Congo (Kinshasa) host columbite-tantalite deposits; columbite-tantalite is known locally as coltan (Fetherston, 2004, p. 71). Columbite-tantalite was mined in Congo (Kinshasa) by artisanal methods. KEMET reported that tantalum raw materials from Kisengo Mine, Katanga Province, was processed at Tantalum Resources (Johannesburg, South Africa) (KEMET Corp., 2015). In 2014, Congo (Kinshasa) was the second-leading producer of tantalum.

Egypt.—Tantalum Egypt JSC [Gippsland Ltd. (Claremont, Western Australia, Australia) and the Government of Egypt] planned to mine tantalite from the Abu Dabbab tantalum-tin-feldspar deposit and Nuweibi deposits. Tantalum Egypt mined tin until September 2013. Gippsland reported 33.18 Mt of reserves at 0.0252% Ta_2O_5 at Abu Dabbab and 142.5 Mt of resources at 0.0176% Ta_2O_5 at Abu Dabbab and Nuweibi. Gippsland planned to complete a definitive feasibility study in 2015 for open pit mining of 2 Mt of ore per year, which would yield 2,750 t/yr of concentrate grading 10% Ta_2O_5 and 50% tin. Tin smelting would produce tantalum glass grading 20% to 30% Ta_2O_5 for which Gippsland has an offtake agreement with H.C. Starck GmbH. Annual production would be about 270 t of tantalum (as Ta_2O_5 contained in glass) (Gippsland Ltd., 2014, p. 2–3, 8).

Estonia.—Molycorp Silmet (Sillamae) produced ferroniobium-tantalum and other niobium and tantalum products from raw materials (ferroniobium-tantalum, tantalite, columbite, and niobium hydroxide) (Molycorp, Inc., 2015, p. 11, 44).

Ethiopia.—The Ethiopian Mineral Development Share Company (EMDSC) (Addis Ababa) owned and managed the Kenticha Tantalum Mine, which produced tantalite concentrate from the tantalite ore with production capacity of about 200 t/yr. EMDSC suspended production in April of 2012 (Bekele, 2013). EMDSC sought investors to develop a tantalite concentrate processing plant to produce downstream tantalum products. EMDSC negotiated with CVMR Corp. (Canada) for first right of refusal to purchase tantalite concentrate (Canadian Council on Africa, 2014).

Gabon.—Eramet S.A. (Paris, France) planned to build a pilot plant to test and prove a recovery process for the Mabounie polymetallic pyrochlore deposit. The Mabounie Project is located by the Ngounie River in Moyen-Ogooue Province, about 50 km from the town of Lambarene. Eramet planned to recover niobium, rare earths, and uranium (Eramet S.A., 2014a, p. 27; 2014b; undated).

Greenland.—Tanbreez Greenland A/S applied for a license to explore for niobium and tantalum in addition to feldspar, hafnium, rare earths, and zirconium at the Kringlerne/Killavaat Alannguat deposit in south Greenland. Other deposits that are prospective for niobium resources are the Safartoq deposit in western Greenland and the Qeqertaasak carbonatite.

Kazakhstan.—Ulba Metallurgical Plant JSC, a subsidiary of Kazatomprom National Atomic Co., produced niobium and tantalum products from raw materials (Kazatomprom National Atomic Co., 2015).

Kenya.—Pacific Wildcat Resources Corp. (Vancouver, British Columbia, Canada) explored for niobium and rare earths at Mrima Hill, where it reported a niobium inferred resource (to a cutoff grade of 0.2% Nb_2O_5) of 94.4 Mt at 0.73% Nb_2O_5 (Pacific Wildcat Resources Corp., 2015). Pacific Wildcat planned to complete additional metallurgical work to support a Preliminary Economic Assessment Study for Mrima Hill.

Malawi.—Globe Metals & Mining Ltd. (West Perth, Western Australia, Australia), through its Kanyika project, sent niobium ore samples to Guangzhou Research Institute of Non-Ferrous Metals (China) to develop a recovery process (Mining in Malawi, 2014).

Rwanda.—Solomon Resources Ltd. explored for niobium, tantalum, and tin minerals at its Rurembo license prospecting area located in Muhanga district, Southern Province. Solomon targeted Gipfizi Ridge near the town of Gitarama for further exploration (Solomon Resources Ltd., 2013). In 2014, Rwanda was the leading country in mine production of tantalum.

Saudi Arabia.—Tertiary Minerals plc awaited an exploration license for the Ghurayyah tantalum-niobium deposit (Tertiary Minerals plc, 2014, p. 11).

Spain.—Iberian Minerals Ltd. [formerly Solid Resources Ltd. (Vancouver, British Columbia, Canada)] explored for lithium, tantalum, and tin minerals at its Alberta 1 project. Solid Resources planned to update its resource estimates and conduct a scoping study (Iberian Minerals Ltd., 2014; Solid Resources Ltd., 2014).

Outlook

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

Tantalum.—Tantalum mine production is forecast to increase to 1,680 t in 2017 from 1,090 t in 2012, which represents an average annual growth rate of 9%. In addition, the amount of tantalum from tin mining and from recycling is expected to increase. The quantity of tantalum produced from tin mining will depend on the demand for tin. Tantalum from recycling will depend on the price of tantalum concentrate. As the price of tantalum concentrate rises, more recycling of tantalum will become economic. Based on reported expansion plans for existing mines and expansion of recycling and tantalum from tin, a growing deficit is forecast. Deficit of primary production of tantalum ore could be mitigated by the use of inventories held along the supply chain (Zogbi, 2012, p. 92–94). 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 will be needed to account for that amount of material. Current producers collectively are expected to increase production by 600 t of tantalum, and projects currently being planned will increase production by more than 1,300 t of tantalum. Thus, expansions at existing operations and projects in the pipeline are more than adequate to meet anticipated growth. Processing capacity will 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).

As microelectronic use increases, so shall tantalum sputtering target use, assuming no significant technological change. Tantalum alloys have high strength and high-temperature resistance, making them useful in jet and rocket engine applications. High corrosion resistance makes tantalum alloys and tantalum coatings useful in chemical process applications or other severe industrial applications. Thus, tantalum use in superalloys and tantalum alloys is expected to follow trends in aircraft jet engines and chemical plant construction and renovation. Tantalum carbide is very hard and temperature resistant and is used in cutting tools, machine tool bits, and teeth in construction, drilling, and mining equipment. As such, tantalum use would be expected to change in response to changes in construction, drilling, metal manufacturing, and mining activities. In addition to being used as precursors to other chemicals, tantalum chemicals are used in a wide variety of applications including optoelectronics, optical element coating, piezoelectronics, CVD deposition, and powder metallurgy. The large number of tantalum chemicals with a wide variety of uses results in a highly fragmented market (Zogbi, 2012, p. 42–47, 51, 64, 66, 72).

Tantalum consumption is forecast to reach 3,000 t in 2017 from 2,000 t in 2012, yielding an average annual growth rate of 8.4%. For the end-use markets used in the referenced study, consumption is expected to increase for all categories, but at different average annual growth rates. From 2012 to 2017, the annual average growth rate for the consumption of powder for capacitors is expected to be 6%, to 981 t in 2017 from 726 t in 2012; powder for carbide, 1%, to 168 t from 159 t; powder for alloys, 1%, to 281 t from 263 t; tantalum ingot, 7%, to 209 t from 150 t; tantalum chemicals, 2%, to 454 t from 417 t; and mill products and other, 2%, to 367 t from 327 t (Zogbi, 2012, p. 74–90).

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TABLE 1
SALIENT NIOBIUM STATISTICS[1]

		2010	2011	2012	2013	2014
United States:						
Exports, Nb content[2]	metric tons	281	363	385	435	1,110
Imports for consumption:						
Mineral concentrates, Nb content	do.	5	23	32	75	101
Niobium metal, gross quantity[3]	do.	1,380	1,460	1,440	1,360	1,870
Niobium oxide, Nb content[e]	do.	824	1,120	1,220	997	1,020
Ferroniobium, Nb content[e]	do.	6,280	6,910	7,430	6,140	8,120
Reported consumption, Nb content						
Raw materials	do.	W	W	W	W	W
Ferroniobium and nickel niobium	do.	5,590	9,060	7,460	7,500	8,210
Apparent consumption, Nb content	do.	8,210	9,160	9,730	8,140	10,000
Value:[4]						
Niobium ores and concentrates (gross quantity)	dollars per kilogram	19.84	39.34	23.54	16.96	14.94
Niobium oxide (gross quantity)	do.	30.32	37.69	44.43	43.47	37.04
Ferroniobium (gross quantity)	do.	24.01	26.43	27.63	27.29	25.78
World, production of niobium-tantalum concentrates, Nb content	metric tons	49,000 r	50,100 r	62,700	57,000 r, e	55,900 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]

(Metric tons of contained tantalum, except where noted otherwise)

		2010	2011	2012	2013	2014
United States:						
Exports:						
Tantalum ores and concentrates[2]		58	65	124	107	126
Tantalum metal		246	443	341	591	422
Tantalum and tantalum alloy powder		134	140	111	146	206
Imports for consumption:						
Mineral ores and concentrates		9	60	82	200	273
Tantalum metal and tantalum-bearing alloys[3]		1,590	1,800	932	904	960
Reported consumption, raw materials		W	W	W	W	W
Apparent consumption		1,160	1,210	437	260	479
Price, tantalite,[4] Ta_2O_5 content	dollars per kilogram	120	275	239	260	221
Value,[5] tantalum ores and concentrates, gross quantity	do	32	46	45	68	69
World, production of niobium-tantalum concentrates, Ta content		922 r	1,000 r	1,110 r	1,210 r, e	1,200 e

eEstimated. rRevised. 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)

	2013	2014
End use:		
Steel:		
Carbon	1,250	1,680
Stainless and heat-resisting	828	918
Full alloy	(2)	(2)
High-strength low-alloy	747	757
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	3,080	3,160
Total	5,900	6,510
Superalloys	1,580	1,680
Alloys (excluding steels and superalloys)	21	23
Grand total	7,500	8,210
Stocks, December 31:		
Consumer	388	381
Producer[3]	W	W
Total	388	381
National Defense Stockpile, total uncommitted inventory by material:		
Niobium metal ingots	10.0	10.0
Tantalum carbide powder	1.80	1.80

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	2013 Gross quantity (kilograms)	2013 Value (thousands)	2014 Gross quantity (kilograms)	2014 Value (thousands)	Principal destinations and sources in 2014 (gross quantity in kilograms and values in thousand dollars)
	Exports:					
	Niobium:					
2615.90.6030	Ores and concentrates	111,000	$1,430	59,600	$772	China 50,900, $632; United Kingdom 4,420, $110; France 1,340, $9; India 1,010, $7; Russia 991, $7; Australia 854, $6.
7202.93.0000	Ferroniobium	588,000	7,280	1,620,000	22,900	Canada 1,300,000, $20,400; Mexico 202,000, $2,230; Peru 16,900, $186; Taiwan 3,100, $34.
	Tantalum:					
2615.90.3000	Synthetic concentrates	61,300	744	160,000	2,290	China 140,000, $2,260; Mexico 20,400, $26; South Africa 386, $4.
2615.90.6060	Ores and concentrates	204,000	3,990	225,000	5,940	Brazil 151,000, $4,390; China 69,200, $1,440; France 4,890, $108; Israel 154, $3.
8103.20.0030	Unwrought, powders	146,000	75,700	206,000	100,000	Mexico 133,000, $65,200; El Salvador 21,600, $4,240; Germany 19,100, $12,100; Czech Republic 10,700, $9,020; Austria 7,940, $2,400; Israel 7,730, $4,030; Luxembourg 1,810, $883.
8103.20.0090	Unwrought, alloys and metal	15,000	8,000	40,200	9,740	China 18,100, $564; Germany 12,000, $4,600; Netherlands 2,680, $1,200; Australia 2,830, $1,060; Panama 2,240, $1,060; United Kingdom 1,010, $371.
8103.30.0000	Waste and scrap	521,000	67,800	325,000	49,300	Mexico 84,600, $18,700; Kazakhstan 71,400, $10,400; Japan 57,100, $7,570; United Kingdom 39,600, $3,460; Germany 26,000, $5,200; Israel 8,950, $358; Australia 8,570, $750.
8103.90.0000	Wrought	54,200	36,400	56,900	36,100	Germany 19,300, $12,400; Mexico 16,500, $9,680; Kazakhstan 4,060, $1,280; Japan 3,390, $2,550; Republic of Korea 3,090, $2,780; Madagascar 2,430, $1,020; China 1,950, $1,540; Canada 1,850, $992.
	Total	XX	201,000	XX	227,000	
	Imports for consumption:					
	Niobium:					
2615.90.6030	Ores and concentrates	8,470	600	2,000	148	China 2,000, $148.
2825.90.1500	Oxide	1,430,000	62,000	1,460,000	55,000	Brazil 795,000, $31,000; Russia 425,000, $14,000; Thailand 100,000, $3,310; China 83,800, $2,980; Spain 30,000, $1,260; Estonia 15,000, $630; Germany 9,420, $837; India 1,000, $35.
	Ferroniobium:					
7202.93.4000	Silicon < 0.4%	390,000	18,500	774,000	35,400	Brazil 627,000, $28,700; United Kingdom 110,000, $5,130; Germany 37,300, $1,660.
7202.93.8000	Other	9,060,000	248,000	11,700,000	305,000	Brazil 9,420,000, $242,000; Canada 2,250,000, $62,000; China 20,900, $569; Portugal 17,400, $444.
	Total	9,450,000	267,000	12,500,000	341,000	
8112.92.4000	Unwrought, powders[3]	1,360,000	77,600	1,870,000	95,800	Brazil 1,758,000, $86,800; Germany 58,400, $3,730; Estonia 26,300, $2,870; Spain 18,200, $1,440; Japan 8,760, $602; China 2,150, $326.
	Tantalum:					
2615.90.6060	Ores and concentrates	653,000	54,000	899,000	71,600	Brazil 468,000, $44,900; Rwanda 236,000, $14,600; Australia 74,300, $4,230; Ethiopia 73,500, $5,530; Zaire 30,300, $1,460; Sierra Leone 11,100, $409; Mexico 1,330, $3; China 1,090, $74.
8103.20.0030	Unwrought powders	113,000	51,900	114,000	50,600	Germany 50,300, $22,600; Thailand 27,100, $13,100; China 17,600, $7,080; Kazakhstan 8,020, $3,490; Japan 5,910, $3,590; Czech Republic 4,400, $460.

See footnotes at end of table.

TABLE 4—Continued

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

8103.20.0090	Unwrought, alloys and metal	197,000	73,000	178,000	68,900	China 103,000, $38,500; Kazakhstan 58,600, $22,000; Germany 9,760, $6,060; Hong Kong 3,270, $1,100; United Kingdom 1,450, $613; Luxembourg 1,070, $403.
8103.30.0000	Waste and scrap	527,000	63,000	624,000	72,600	Indonesia 154,000, $7,780; Austria 134,000, $3,730; China 82,000, $16,700; Mexico 61,900, $2,230; Germany 39,300, $12,900; Estonia 29,000, $10,700; Japan 27,500, $5,880; Czech Republic 25,000, $866.
8103.90.0000	Wrought	67,700	41,100	43,800	25,900	China 31,400, $17,500; Kazakhstan 5,040, $3,310; France 2,300, $1,130; Germany 1,030, $688.

[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, 2]

	2013		2014	
Country	Gross quantity (kilograms)	Value (thousands)	Gross quantity (kilograms)	Value (thousands)
Aruba	--	--	456	$10
Australia	25,100	$2,090	74,300	4,230
Bolivia	9,380	602	--	--
Brazil	324,000	28,600	468,000	44,900
Canada	159,000	14,200	--	--
China	20	7	1,090	74
Colombia	--	--	100	6
Congo (Kinshasa)	25,400	1,690	30,300	1,460
Ethiopia	--	--	73,500	5,530
Germany	20	5	1,940	216
India	--	--	531	11
Madagascar	--	--	711	42
Mexico	120	19	1,330	3
Mozambique	30,200	1,110	--	--
Rwanda	37,000	2,520	236,000	14,600
Sierra Leone	12,600	468	11,100	409
South Africa	26,300	1,680	--	--
Tanzania	4,080	999	--	--
Total	653,000	54,000	899,000	71,600

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff System 2615.90.6060.

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 quantity[3] 2010	2011	2012	2013[e]	2014[e]	Niobium content[4] 2010	2011	2012	2013[e]	2014[e]	Tantalum content[4] 2010	2011	2012	2013[e]	2014[e]
Australia, columbite-tantalite[6]	NA r	NA r	NA r	NA r	NA	NA r	NA r	NA r	NA r	NA	50	50	50	50	50
Bolivia, tantalite	3	17	42	47	NA	--	--	--	--	--	1	4	9	10	5
Brazil:															
Nb minerals[e, 7, 8]	113,000	115,000	147,000	136,000	NA	44,270 9	45,198 9	57,471 9	51,497 9	50,000 9	--	--	--	--	--
Ta minerals[6, 10]	587 e	453 e	393 e	400	NA	--	--	--	--	--	144	111	98	152	150
Burundi	67	159	229 r	100 r	NA	13	31 e	45 r, e	20 r	30	13	31 e	50 e	14 e	14
Canada:															
Nb minerals[8]	1,792,000	2,087,000	2,155,000	2,300,000	NA	4,298 r	4,551 r	4,705 r	4,916 r	5,480 9	--	--	--	--	--
Ta minerals[e, 6, 10]	-- 9	40	80	20	NA	--	1	3	1	NA	--	--	37	9	--
China[e]	NA	NA	NA	NA	NA	22	17	14	15	20	70	61	66	60	60
Congo (Kinshasa):															
Cassiterite concentrate	13,415	9,267	8,018	6,231	NA	130	90	80	60	NA	190	140	120	90	90
Columbite-tantalite[11]	440	536	586	500	NA	80 e	90 e	100 e	90	90	100 e	120 e	130 e	110	110
Nb minerals[e]	--	--	-- 9	--	--	--	--	-- 9	-- 9	--	--	--	--	-- 9	--
Ethiopia, tantalite[12]	252	285	380 e	30 r	NA	22	25	26 e	2 r	20	82 7	95 7	91 7	10	40
French Guiana, columbite-tantalite[e]	2	2	2	2	NA	--	--	--	--	--	(13)	(13)	(13)	(13)	NA
Kazakhstan, niobium	NA	NA	43	44	NA	NA	NA	NA r	NA r	NA	NA	NA	(13)	(13)	NA
Mozambique[e]	55 9	139 9	408 9	410 r, 9	NA	4	10	29	30 r	20	15	39	83	43	23
Nigeria, columbite-tantalite[e]	281	311	310	300	NA	20	22	22	21	20	58	64	63	60	60
Rwanda[e]															
Cassiterite concentrate	5,290	6,950	4,640	4,900	NA	-- r	-- r	-- r	-- r	--	80	100	70	70	70
Columbite-tantalite	560	250 r	600 r, 9	1,000 r	NA	180 r	80 r	190 r	320 r	200	120	190	240	530	530
Uganda[e]	-- r	-- r	-- r	-- r	--	-- r	-- r	-- r	-- r	--	-- r	-- r	-- r	-- r	--
Total	1,930,000	2,220,000	2,320,000	2,450,000	NA	49,000 r	50,100 r	62,700	57,000 r	55,900	922	1,000 r	1,110 r	1,210 r	1,200

[e]Estimated. [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]Except for Congo (Kinshasa) and Rwanda, excludes production of niobium and tantalum contained in tin ores. Includes data available through October 1, 2015.

[3]Gross quantity is quantity 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, Russia also produces, or is thought to produce, niobium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[6]Tantalum production reported in Ta_2O_5 converted to tantalum content. Gross quantity 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 quantity is concentrate assumed to be one-third Nb_2O_5.

[8]Includes columbite and pyrochlore.

[9]Reported figure.

TABLE 6—Continued

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

[10]Includes djalmaite and tantalite.
[11]Reported data includes the North Kivu and South Kivu Provinces.
[12]Data are for fiscal year beginning July 1 of that stated.
[13]Less than ½ unit.

TABLE 7

FERRONIOBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, Nb content)

Country[3]	2010	2011	2012	2013	2014[e]
Brazil[4]	52,588 [5]	53,691 [6]	50,562 [6]	46,555 [6]	48,000 [7]
Canada[8]	4,313	4,632	4,707	5,263	5,600 [9]
Russia[e, 10]	420 [9]	420	420	360	360
Total	57,300	58,700	55,700	52,200	54,000

[e]Estimated.
[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes data available through October 1, 2015.
[3]In addition to the countries listed, Austria, China, and Germany are believed to have produced ferroniobium (ferrocolumbium), but production information is inadequate for the formulation of estimates of output levels.
[4]Average grade assumed to have been 65% Nb.
[5]Pereira, R.F., Jr., 2013, Nióbio, *in* Sumário mineral 2013: Brasilia, Brazil, National Department of Mineral Production, v. 33.
[6]Pereira, R.F., Jr., 2014, Nióbio, *in* Sumário mineral 2014: Brasilia, Brazil, National Department of Mineral Production, v. 34.
[7]Extrapolated.
[8]Source: IAMGold/Niobec. Average grade assumed to have been 66% Nb.
[9]Reported figure.
[10]Average grade assumed to have been 60% Nb.