science for a changing world

2005 Minerals Yearbook

COLUMBIUM (NIOBIUM) AND TANTALUM

U.S. Department of the Interior
U.S. Geological Survey

March 2007

Columbium (Niobium) and Tantalum

By Michael J. Magyar

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was prepared by Regina R. Coleman, international data coordinator.

Neither columbium (niobium) nor tantalum was mined domestically because U.S. resources are of low grade. Some resources are mineralogically complex, and most are not currently recoverable. The last significant mining of columbium and tantalum in the United States was during the Korean conflict, when increased military demand resulted in columbium and tantalum ore shortages.

Columbium is vital as an alloying element in steels and in superalloys for aircraft turbine engines and is in greatest demand in industrialized countries. It is critical to the United States because of its defense-related uses in the aerospace, energy, and transportation industries. Substitutes are available for some columbium applications, but in most cases, they are less desirable.

Tantalum is a refractory metal that is ductile, easily fabricated, highly resistant to corrosion by acids, a good conductor of heat and electricity, and has a high-melting point. It is critical to the United States because of its defense-related applications in aircraft, missiles, and radio communications. Substitution for tantalum is made at either a performance or economic penalty in most applications.

Pyrochlore was the principal columbium mineral mined worldwide. Brazil and Canada, which were the dominant pyrochlore producers, accounted for most of the total estimated columbium mine production in 2005, with Brazil alone accounting for about 90%. The two countries, however, no longer export pyrochlore, only columbium in upgraded, valued-added forms produced from pyrochlore. Brazil exported mostly regular-grade ferrocolumbium and columbium oxide, and Canada exported regular-grade ferrocolumbium. The remaining columbium mineral supply came mostly from mining columbite and tantalite in Australia, Nigeria, and certain other African countries. Tantalum mineral was produced mostly from tantalite mining operations in Australia, which accounted for about 58% of total estimated tantalum mine production in 2005, and from other tantalum mine operations in Brazil, Canada, Mozambique, and certain African countries. The United States remained dependent on imports of columbium and tantalum materials; Brazil was the major source for columbium, and Australia was the major source for tantalum. Columbium price quotations reportedly remained stable, and overall price quotations for tantalite ore increased slightly. Overall reported consumption of columbium in the form of ferrocolumbium and nickel columbium increased. Tantalum consumption was unchanged. Summaries of important columbium and tantalum statistics are listed in tables 1 and 2, respectively.

Legislation and Government Programs

To ensure supplies of columbium and tantalum during an emergency, various materials have been purchased for the National Defense Stockpile (NDS) (table 3). For fiscal year 2005 (October 1, 2004, through September 30, 2005), the Defense National Stockpile Center (DNSC) disposed of columbium metal ingots totaling 9 metric tons (t) valued at $245,000. No columbium value was obtained for the 81 t of columbium contained in tantalum concentrates sold by the DNSC in fiscal year 2005. The DNSC's columbium carbide inventory was exhausted in fiscal year 2002, and the ferrocolumbium inventory was exhausted in fiscal year 2001. The DNSC also sold 7 t of tantalum contained in tantalum capacitor-grade metal valued at $829,000, 9 t of tantalum contained in tantalum metal ingots valued at $1.31 million, 9 t of tantalum contained in tantalum oxide valued at $910,000, and 220 t of tantalum contained in tantalum minerals valued at $22.7 million. There were no sales of tantalum carbide powder in fiscal year 2005. As of September 30, tantalum inventory sold but not shipped from the NDS included 1 t of tantalum contained in tantalum metal ingot (U.S. Department of Defense, 2005, p. 10-11, 56).

In its revised Annual Materials Plan (AMP) for fiscal year 2005 and proposed AMP for fiscal year 2006 (October 1, 2005, through September 30, 2006), the DNSC had authority to sell the following columbium and tantalum materials (actual quantity limited to remaining sales authority or inventory, with the exception of columbium concentrates): 254 t of columbium contained in columbium concentrates, 9 t of columbium contained in columbium metal ingots, 227 t of tantalum contained in tantalum minerals, 18 t of tantalum contained in tantalum metal ingots, 18 t of tantalum contained in tantalum metal powder, 9 t of tantalum contained in tantalum oxide, and 2 t of tantalum contained in tantalum carbide powder (Defense National Stockpile Center, 2005).

Production

Neither columbium nor tantalum was mined domestically in 2005. Domestic production data for ferrocolumbium are developed by the U.S. Geological Survey (USGS) from the annual voluntary domestic survey for ferroalloys. Ferrocolumbium production data for 2005, however, were incomplete at the time this report was prepared.

KEMET Corporation of Greenville, SC, the leading U.S.-based capacitor manufacturer, announced it had become the first company to market lead-free Axial Molded (T322), Radial Molded (T340) and Commercial Herm Seal (T110/T140) capacitors. This transition was driven by environmental legislation in Europe, such as end-of-life vehicle, restriction on hazardous substances, and waste electrical and electronic equipment directives aimed at eliminating lead from the manufacture of electronic components. Standard tin/lead versions of these capacitors will continue to be available (Metal-Pages, 2005e§[1]). KEMET introduced a new high-grade, COTS (497) series of tantalum capacitors for use in such applications as industrial power supplies and military portable communications equipment with a need for more robust surge protection (Metal-Pages, 2005d§). Finally, KEMET also announced a new high-temperature (T499) tantalum chip series for use in under-hood automotive and oil exploration environments at temperatures up to 175° C (Metal-Pages, 2005f§).

Cabot Supermetals, Boyertown, PA (a business unit of Cabot Corporation, Boston, MA), announced that it would halt operations at its thin films manufacturing facility in Etna, OH, which opened in August 2004 at a cost of $12 million. Cabot cited high energy costs and weak market conditions as factors in the decision. The facility had produced tantalum-sputtering targets for use in flat-panel displays, magnetics, optics, and semiconductor applications. Cabot stated that it intended to focus on selling tantalum plate to the makers of tantalum-sputtering targets instead of producing them itself. Cabot hoped that this change in business direction would allow it to sell more tantalum and lower production costs. Cabot posted a $52 million loss in its fiscal year ending September 30, 2005, compared with a $15 million profit in fiscal year 2004 (Metal-Pages, 2005j§).

KEMET announced an agreement to buy the tantalum capacitor business of Germany's Epcos AG, which included a plant in Evora, Portugal, and some facilities in Heidenheim, Germany. KEMET intended to keep Epcos employees at the Evora plant but would stop capacitor production in Heidenheim. Heidenheim employees working in development, marketing, and sales of tantalum capacitors would be retained. The transaction was expected to be finalized in the first quarter of 2006 (Metal-Pages, 2005c§).

Consumption

Reported U.S. consumption of columbium in ferrocolumbium and nickel columbium for all end uses increased by 11% compared with that of 2004. Consumption of columbium by the steelmaking industry decreased by 4% overall, with consumption up in the carbon steel end-use category and down in the high-strength low-alloy and stainless steel end-use categories. Demand for columbium in superalloys rose to 1,220 t from 699 t, a 75% increase (table 4). Columbium in superalloys, used in the form of nickel columbium, increased to 899 t from 540 t. U.S. apparent consumption of all columbium was estimated to be 7,400 t, a 10% increase compared with that of 2004.

In 2005, estimated U.S. apparent consumption of all tantalum was 682 t, about the same as in 2004. Tantalum was consumed mostly in the form of alloys, compounds, fabricated forms, ingot, and metal powder. More than 60% of U.S. tantalum was believed to be consumed in the electronics industry, mainly in the form of tantalum capacitors. Major end-uses for tantalum capacitors included automotive electronics, pagers, personal computers, and portable telephones.

Columbium.—Columbium conducts heat and electricity well, has a high melting point (about 2,470° C), is readily fabricated, and is highly resistant to many chemical environments. Columbium in the form of ferrocolumbium is used worldwide, mostly as an alloying element in steels and in superalloys. Because of its refractory nature, appreciable amounts of columbium in the form of high-purity ferrocolumbium and nickel columbium are used in cobalt-, iron-, and nickel-base superalloys for such applications as heat-resisting and combustion equipment, jet engine components, and rocket subassemblies. Columbium carbide is used in cemented carbides to modify the properties of the cobalt-bonded, tungsten-carbide-base material to impart toughness and shock resistance. It is usually used along with carbides of other metals, such as tantalum and titanium. Columbium oxide is the intermediate product used in the manufacture of columbium carbide, columbium metal, high-purity ferrocolumbium, and nickel columbium. Acceptable substitutes, such as molybdenum, tantalum, titanium, tungsten, and vanadium, are available for some columbium applications, but substitution may lower performance and/or cost effectiveness.

Columbium was recycled mostly from products of columbium-bearing steels and superalloys; little was recovered from products specifically for their columbium content. Detailed data on the quantities of columbium recycled in 2005 are not available but may compose as much as 20% of U.S. apparent consumption of columbium (Cunningham, 2004a).

Tantalum.—The major use for tantalum as tantalum metal powder is in the production of electronic components, mainly tantalum capacitors. The tantalum capacitor exhibits reliable performance and combines compactness and high efficiency with good shelf life. Applications for tantalum capacitors include communication systems, computers, and instruments and controls for aircraft, missiles, ships, and weapon systems. Because of its high melting point (about 3,000° C), good strength at elevated temperatures, and good corrosion resistance, tantalum is combined with cobalt, iron, and nickel to produce superalloys that are used in aerospace structures and jet engine components. Tantalum carbide, which is used mostly in mixtures with carbides of such metals as columbium, titanium, and tungsten, is used in boring tools, cemented-carbide cutting tools, farm tools, and wear-resistant parts. Owing to tantalum's excellent corrosion-resistant properties, tantalum mill and fabricated products are used for corrosion- and heat-resistant chemical plant equipment, such as condensers, evaporators, heat exchangers, heating elements, and liners for pumps and reactors. Substitutes, such as aluminum, rhenium, titanium, tungsten, and zirconium, can be used in place of tantalum, but are usually used at either a performance or economic penalty.

Tantalum was recycled mostly from new scrap that was generated during the manufacture of tantalum-related electronic components and new and old scrap products of tantalum containing cemented carbides and superalloys. Detailed data on the quantities of tantalum recycled in 2005 are not available but may compose as much as 20% of U.S. apparent consumption of tantalum (Cunningham, 2004b).

Prices

Published prices for pyrochlore concentrates produced in Brazil and Canada were not available because these concentrates

[1]References that include a section mark (§) are found in the Internet References Cited section.

were consumed internally by producers of regular-grade ferrocolumbium in Brazil and Canada and are no longer being exported. A price for Brazilian pyrochlore has not been available since 1981, and the published price for pyrochlore produced in Canada was discontinued in early 1989. The American Metal Market published price for regular-grade ferrocolumbium was discontinued in February, 2005, with the last price listed at a range of $6.45 to $6.70 per pound of contained columbium, unchanged since July 2003 (American Metal Market, 2005§). The American Metal Market published price for high-purity (vacuum-grade) ferrocolumbium was discontinued in February-March 2002 with the last price listed at a range of $17.50 to $18.00 per pound of contained columbium. The Metal Bulletin price for columbite ore, based on a minimum 65% contained columbium oxide (Nb_2O_5) and tantalum oxide (Ta_2O_5), was discontinued in October 2001 at a range of $5.50 to $7.00 per pound. According to one industry analyst, "Prices for niobium oxide, other niobium chemicals, niobium metal and various alloys derived from either pyrochlore or other niobium-bearing sources are highly variable and depend on product specifications, volume, and processing considerations" (Mosheim, 2003a).

The price for tantalum products mostly is affected by events in the supply of and demand for tantalum minerals. Yearend 2005 published prices for tantalite ore (per pound of contained Ta_2O_5) were as follows: Platts Metals Week, a range of $35 to $40, unchanged since November 2004 (Platts Metals Week, 2006); Metal Bulletin Weekly, a range of $34 to $38, unchanged since December 8, 2004 (Metal Bulletin Weekly, 2006); and Ryan's Notes, a range of $30 to $35, unchanged since August 2004 (Ryan's Notes, 2006). The Metal Bulletin published price for Greenbushes, Australia, tantalite ore was $40 per pound of contained Ta_2O_5, 40% basis, unchanged since March 2002 (Metal Bulletin Weekly, 2006). According to one industry analyst, "The pricing of tantalum chemicals, metal powders, alloys, and fabricated articles is generally established by negotiation between buyer and seller. Specifications for a particular chemical, metal powder, or fabricated article of metal or tantalum alloy are dictated by the application and its influence on processing requirements, and the volume of a specific product; all influence the prices negotiated between buyer and seller" (Mosheim, 2003b).

Based on the revised AMP for fiscal year 2006, the remaining NDS inventory of columbium metal ingots and minerals and tantalum carbide powder, metal ingots, minerals, and oxide could be exhausted in 2006. However, large inventories of tantalum materials at major processors and adequate production capacity at producers should minimize any impact on tantalum prices.

Foreign Trade

Table 5 lists columbium and tantalum export and import data. For exports, overall trade value decreased by 29%, while total gross weight increased slightly compared with those of 2004. In descending order, Israel, the Czech Republic, Germany, Kazakhstan, the United Kingdom, Mexico, Japan, France, and Thailand were the major recipients of the columbium and tantalum materials, on the basis of value, with more than 80% of the total. For imports, overall trade value decreased by 9% and total gross weight increased slightly. In descending order, Brazil, Japan, Australia, China, Kazakhstan, Germany, Thailand, and Canada were the major sources of columbium and tantalum imports, on the basis of value, with 90% of the total.

Imports for consumption of columbium ores and concentrates increased by 5 t compared with those of 2004 (table 6); imports at an assumed average grade of approximately 32% Ta_2O_5 and 30% Nb_2O_5 were estimated to contain 2.6 t of tantalum and 2.0 t of columbium. Ferrocolumbium imports rose by 5%, with Brazil accounting for 88% of the total. Brazil accounted for 72% of total value of columbium imports.

Imports for consumption of tantalum ores and concentrates were down by 16% compared with those of 2004 (table 7); imports from Australia accounted for 79% of quantity and 86% of value. Imports at an assumed average grade of approximately 37% Ta_2O_5 and 16% Nb_2O_5 were estimated to contain 379 t of tantalum and 140 t of columbium.

Brazil, which was the major source for U.S. columbium imports, accounted for 83% of the total, in units of contained columbium, and Australia, which was the major source for U.S. tantalum imports, accounted for 39% of the total, in units of contained tantalum (fig. 1, 2).

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic columbium and tantalum production to meet U.S. demand. For columbium in 2005, net import reliance as a percentage of apparent consumption was 100%. For tantalum, net import reliance as a percentage of apparent consumption was estimated to be 90% owing to sales by the NDS.

World Industry Structure

Principal world columbium and tantalum raw material and product producers are listed in tables 8 and 9, respectively. Annual world production of columbium and tantalum mineral concentrates, by country, is listed in table 10. Brazil and Canada were the major producers of columbium mineral concentrates, and Australia, Brazil, Canada, and Mozambique were the major producers of tantalum mineral concentrates. In addition to production reported in the annual world production table, tantalum was available from tantalum-bearing tin slags, which are byproducts from tin smelting, principally from Asia, Australia, and Brazil. However, tantalum recovery from tin slags is not a major source of tantalum.

World Review

Australia.—The administrators of Sons of Gwalia Ltd. (SOG) were expected to resolve the price dispute between SOG and Cabot in the first quarter of 2006. The West Perth firm, which went into administration in 2004, agreed to a new long-term tantalum supply contract with Cabot; however, the two firms were unable to agree on how the payment would be calculated. The method of calculation in the expired contract would result in a price substantially above current market prices for tantalum concentrate. The new contract provides for supply of tantalum concentrates from SOG's Wodgina Mine in Western Australia for the calendar years 2006 through 2010. SOG sells about 900 metric tons per year (t/yr) (2 million pounds per year) of tantalum oxide to Cabot and H.C. Starck Inc. (Metal-Pages, 2005a§).

Brazil.—British junior explorer Angus & Ross Plc. obtained an option to buy the license block Caicara, near Pedra Branca in the Mato Grosso State in western Brazil. Caicara has quantified tantalum reserves of 167,000 t grading 432 grams per metric ton of tantalum oxide. Angus & Ross planned confirmatory drilling in early 2006 followed by a decision possibly to build a small processing plant (Metal-Pages, 2005i§).

Companhia Brasileira de Metalurgia e Mineração (CBMM), the world's leading producer of columbium from pyrochlore, increased its capacity to produce ferrocolumbium to 54,000 t/yr with the addition of a new electric furnace in July. In October, CBMM expanded the capacity of its concentrate processing facilities to 140,000 t/yr of columbium at its plant near Araxa in Minas Gerais State. By the end of 2006, CBMM planned to expand ferrocolumbium capacity to 70,000 t/yr to meet expected increased demand from Asia (China, Japan, and the Republic of South Korea) and Europe (Tex Report, 2005§).

Canada.—In 2005, Cambior Inc.'s revenue from the production of columbium at the Niobec Mine in St. Honore, 15 km northwest of Chicoutimi, Quebec, increased by 48.6% compared with that of 2004 owing to its acquisition of the remaining 50% interest in the Niobec Mine from Sequoia Minerals Inc. in 2004. Cambior completed a mill expansion and optimization of the concentrate recovery circuit in the third quarter of 2005 that was expected to increase mine production capacity by 20%. After the expansion, the Niobec Mine, in operation since 1976, had the capacity to produce 4,000 t/yr of columbium contained in ferrocolumbium (Metal-Pages, 2005g§).

Saudi Arabia.—A representative of Tertiary Minerals Plc. announced that its wholly owned Ghurayyah columbium and tantalum project in Saudi Arabia was the world's largest deposit, with tantalum resources estimated to be 94,000 t (207 million pounds) of tantalum oxide. The pre-feasibility study was expected to be completed in 2006, and a bankable feasibility study, in 2007. If these feasibility studies are positive, Tertiary could take advantage of favorable government-secured financing in Saudi Arabia, which would limit the amount of external equity Tertiary would need to raise to 12.5%. For comparison, Tertiary estimated the tantalum resources at SOG's Greenbushes' and Wodgina's Mines to be 56,000 t and 40,000 t (124 million pounds and 89 million pounds), respectively (Metal-Pages, 2005b§).

Outlook

Columbium.—The principal use for columbium will continue to be as an additive in steelmaking, mostly in the manufacture of microalloyed steels. The production of high-strength low-alloy steel is the leading use for columbium, and the trend for columbium consumption, domestically and globally, will continue to follow closely that of steel production, as the steel industry is estimated to account for as much as 90% of columbium consumption. (Additional information about the future of the steel industry can be found in the Iron and Steel chapter of the USGS Minerals Yearbook, Volume I, Metals and Minerals.)

According to Roskill Information Services Ltd. (2005, p. 1), world-wide columbium consumption reached a record level in 2003 and grew further in 2004, inline with increased steel production. Roskill expected further expansion in 2005 and 2006. Demand for columbium, however, does not mirror trends in overall steel production, as only 10% of the total steel produced contains columbium. In addition, the geographical distribution of consumption is very uneven. In China, where the growth in steel output has been greatest, the incidence of columbium use reportedly was much lower than in Western countries. This would agree with observations of consumption of other ferroalloys per unit of steel. As a result, there is significant potential for increased demand for columbium in steel, both from growth in total steel output and also from changes in columbium composition.

The leading nonsteel use of columbium is in superalloys for, among other applications, aircraft engines. Those markets experienced a sharp fall after the terrorist attacks on September 11, 2001, resulted in an economic downturn, and the outbreak of severe acute respiratory syndrome caused travel to decline. The commercial aircraft market has since begun to recover and is expanding strongly. For instance, Boeing Company expected the airline fleet to more than double over the next 20 years, with the addition of more than 27,000 new aircraft (Boeing Company, 2006, p. 4). Nickel-base superalloys (such as alloy 718, which contains about 5% columbium) can account for about 40% to 50% of aircraft engine weight, and they are expected to be the materials of choice for the future owing to their high-temperature operating capability (Cunningham, 2004a, p. I7).

An emerging market for columbium was displacing tantalum in capacitors, owing to columbium's relatively low cost and abundant supply, but development of columbium capacitors has been slowed by technical difficulties. While there has been development of columbium capacitors that can be used in some applications, tantalum content per capacitor has decreased limiting the potential for market penetration by columbium.

Tantalum.—The main uses for tantalum are in alloys, capacitors, carbides, medical applications, and in the chemical industry, with capacitors accounting for more than 50% of consumption. Capacitors are used in digital cameras, laptops, mobile phones, video phones, and other electronic devices. The Tantalum-Niobium International Study Center expected tantalum consumption to grow by 7% per year, mainly owing to the increase in demand for capacitors. In the capacitor market segment, smaller case sizes reduced tantalum consumption per unit and tantalum lost market share to other materials, such as aluminum, ceramics, and columbium (Metal-Pages, 2005h§).

New sources of tantalum may eliminate the sharp price fluctuations of recent years (Roskill Information Services Ltd., 2005). While Australia supplied 50% of tantalum production in 2005, other significant production came from Africa, Brazil, Canada, and China, so supply was expected to be sufficient. Future supply prospects are based on reserves in Egypt, Greenland, and Saudi Arabia, and there are numerous deposits of tantalum that could be brought into production given the right market conditions. Some large projects, such as Abu Dabbab in Egypt, were already in advanced stages of development; however, future development may be keyed to depletion of Australian resources.

An important component of world tantalum supply is the U.S. Government sales of tantalum materials from the NDS. Based on the AMP for fiscal year 2006, the NDS inventory of tantalum metal powder, ingots, and oxide could be exhausted in 2006, while the inventory of tantalum carbide powder and minerals could be exhausted in 2007. However, large inventories of tantalum materials at major processors and adequate production capacity at producers should minimize any impact on tantalum prices.

References Cited

Boeing Company, 2006, Current market outlook—Executive overview: Chicago, IL, Boeing Company, September, 48 p.

Cunningham, L.D., 2004a, Columbium (niobium) recycling in the United States in 1998, *in* Sibley, S.F., ed., Flow studies for recycling metal commodities in the United States: U.S. Geological Survey Circular 1196–A—M, p. I1-I9.

Cunningham, L.D., 2004b, Tantalum recycling in the United States in 1998, *in* Sibley, S.F., ed., Flow studies for recycling metal commodities in the United States: U.S. Geological Survey Circular 1196–A—M, p. J1-J10.

Defense National Stockpile Center, 2005, Revised annual materials plan for FY 2006: Fort Belvoir, VA, Defense National Stockpile Center news release, November 14, 2 p.

Metal Bulletin Weekly, 2006, [untitled]: Metal Bulletin Weekly, no. 8925, January 2, p. 32.

Mosheim, C.E., 2003a, Niobium, *in* Mining annual review 2003: London, United Kingdom, Mining Communications Ltd. CD-ROM.

Mosheim, C.E., 2003b, Tantalum, *in* Mining annual review 2003: London, United Kingdom, Mining Communications Ltd. CD-ROM.

Platts Metals Week, 2006, [untitled]: Platts Metals Week, v. 77, no. 1, January 2, p. 20.

Roskill Information Services Ltd., 2005, The economics of niobium (10th ed.)—Prepublication summary: London, United Kingdom, Roskill Information Services Ltd., 1 p.

Ryan's Notes, 2006, [untitled]: Ryan's Notes, v. 12, no. 1, January 2, p. 10.

U.S. Department of Defense, 2005, Strategic and critical materials report to the Congress—Operations under the Strategic and Critical Materials Stock Piling Act during the period October 2004 through September 2005: Washington, DC, U.S. Department of Defense, 66 p.

Internet References Cited

American Metal Market, 2005 (January 19), AMM's nonferrous metal prices to be modified week of February 14, accessed January 12, 2005, at URL http://amm.com/2005-01-19__12-13-02.html.

Metal-Pages, 2005a (December 15), Cabot says Gwalia dispute should be resolved Q1 latest, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21634.

Metal-Pages, 2005b (October 24), Ghurayyah—The next tantalum giant, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=20987.

Metal-Pages, 2005c (December 13), KEMET buys Germany capacitor business, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21587.

Metal-Pages, 2005d (November 1), KEMET introduces new high-grade capacitor, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21079.

Metal-Pages, 2005e (October 3), KEMET launches lead-free capacitor components, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=20748.

Metal-Pages, 2005f (December 19), KEMET launches new tantalum chip series, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21666.

Metal-Pages, 2005g (November 5), Loss narrows for Nb major, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21148.

Metal-Pages, 2005h (May 11), New supplies could control Ta market, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=19076.

Metal-Pages, 2005i (August 30), Ta option for Angus & Ross, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=20331.

Metal-Pages, 2005j (December 5), Ta sputtering target exit for Cabot, accessed January 12, 2007, at URL http://www.metal-pages.com/subscr/story.php?id=21716.

Tex Report, 2005 (November 25), CBMM/Brazil increases capacity for Fe-Nb production, accessed January 12, 2007, at URL http://www.texreport.co.jp/xenglish/eng-genryou/200511/200511251046Fri-4.html.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Columbium (Niobium). Ch. in Metal Prices in the United States through 1998, 1999.

Columbium (Niobium). Ch. in Mineral Commodity Summaries, annual.

Columbium (Niobium) and Tantalum. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Columbium (Niobium) Recycling in the United States in 1998. Ch. in Flow Studies for Recycling Metal Commodities in the United States, Circular 1196–A—M, 2004.

Historical Statistics for Mineral and Material Commodities in the United States. Open-File Report OF-01-006, 2003.

Niobium (Columbium) and Tantalum. International Strategic Minerals Inventory Summary Report, Circular 930-M, 1993.

Recycling—Metals. Ch. in Minerals Yearbook, annual.

Tantalum. Ch. in Metal Prices in the United States through 1998, 1999.

Tantalum. Ch. in Mineral Commodity Summaries, annual.

Tantalum Recycling in the United States in 1998. Ch. in Flow Studies for Recycling Metal Commodities in the United States, Circular 1196–A—M, 2004.

Other

Aerospace Industries Association.

American Metal Market, daily.

Columbium (Niobium). Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

Company reports and news releases.

Defense National Stockpile Center reports and news releases.

Federal Register, daily.

Metal Bulletin, daily, weekly, and monthly.

Mining & Metals Report. Interfax International Ltd., weekly.

Ores & Alloys for the Global Steel Industry. Metal Bulletin Books Ltd., 2000.

Mining Journal, weekly.

Northern Miner, The.

Platts Metals Week, weekly.

Roskill Information Services Ltd.:

Economics of Niobium, The (9th ed.), 2002.

Economics of Tantalum, The (8th ed.), 2002.

Roskill's Letter from Japan, monthly.

Ryan's Notes, weekly.

Tantalum. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

International Symposium Proceedings. Tantalum-Niobium International Study Center, 2005.

TABLE 1

SALIENT COLUMBIUM STATISTICS[1]

		2001	2002	2003	2004	2005
United States:						
Government stockpile releases, Nb content[2]	metric tons	-4	9	223	112 r	128
Production of ferrocolumbium, Nb content	do.	NA	NA	NA	NA	NA
Exports, columbium metal, compounds, alloys, gross weight	do.	NA	NA	NA	NA	NA
Imports for consumption:						
Mineral concentrates, Nb content[e]	do.	280 r	270 r	180	165	140
Columbium metal and columbium-bearing alloys, Nb content[e]	do.	1,050	673	743	940	1,380
Columbium oxide, Nb content[e]	do.	1,360	660	590	630	661
Ferrocolumbium, Nb content[e]	do.	4,480	4,030	4,080	5,170	5,430
Tin slag, Nb content	do.	NA	NA	NA	NA	NA
Consumption, Nb content:						
Raw materials	do.	NA	NA	NA	NA	NA
Ferrocolumbium and nickel columbium[e]	do.	1,300 r	2,740 r	3,220 r	3,760 r	4,170
Apparent	do.	7,090 r	5,520 r	5,600 r	6,850 r	7,400
Prices:						
Columbite[3, 4]	dollars per pound	NA	NA	NA	NA	NA
Ferrocolumbium[5]	do.	6.88	6.60	6.58	6.56	6.56
Pyrochlore[6]	do.	NA	NA	NA	NA	NA
World, production of columbium-tantalum concentrates, Nb content	metric tons	31,100	45,100 r	40,800 r	37,900 r	38,700

[e]Estimated. [r]Revised. NA Not available.

[1]Data are rounded to no more than three significant digits, except prices.

[2]Net quantity (uncommited inventory). Negative numbers indicate an increase in inventory.

[3]Yearend average value, contained pentoxides for material having a columbium pentoxide (Nb_2O_5) to tantalum pentoxide ratio of 10 to 1.

[4]The published price for columbite ore was discontinued in October 2001 at a range of $5.50 to $7.00 per pound of Nb_2O_5 content.

[5]Yearend average value of contained Nb, standard (steelmaking) grade.

[6]Yearend average value of contained pentoxide.

TABLE 2

SALIENT TANTALUM STATISTICS

		2001	2002	2003	2004	2005
United States:						
Government stockpile releases, Ta content[1]	metric tons	-53	16	335	205 r	245
Exports, gross weight:						
Tantalum ores and concentrates[2]	do.	530	232	295	717	479
Tantalum metal, compounds, alloys	do.	486	265	187	504 r	567
Tantalum and tantalum alloy powder	do.	156	188	280	257	242
Imports for consumption, Ta content:						
Mineral concentrates	do.	700 r	730 r	480 r	450	380
Tantalum metal and tantalum-bearing alloys[3]	do.	317 r	266	249	584 r	485
Tin slag	do.	NA	NA	NA	NA	NA
Consumption, Ta content:						
Raw materials	do.	NA	NA	NA	NA	NA
Apparent	do.	698 r	658 r	512 r	674 r	682
Prices, tantalite[4]	dollars per pound	37	31	28	33.5	34.5
World, production of columbium-tantalum concentrates, Ta content	metric tons	1,170 r	1,460 r	1,280	1,390 r	1,260

[r]Revised. NA Not available.

[1]Net quantity (uncommited inventory). Negative numbers indicate an increase in inventory.

[2]Includes reexports.

[3]Exclusive of waste and scrap.

[4]Yearend average value of contained pentoxides.

TABLE 3
COLUMBIUM AND TANTALUM MATERIALS IN NATIONAL DEFENSE STOCKPILE INVENTORIES AS OF DECEMBER 31, 2005[1]

(Metric tons, columbium or tantalum content)

			Uncommitted			
Material	Stockpile goal[2]	Disposal authority	Stockpile-grade	Non-stockpile-grade	Total	Committed
Columbium:						
Concentrates[e]	189		254	146	254	64
Carbide powder	--	--	--	--	--	--
Ferrocolumbium	--	--	--	--	--	--
Metal ingots[e]	19	--	9	--	9	--
Total	208	--	263	146	263	64
Tantalum:[e]						
Minerals	348		227	226	452	--
Carbide powder	6	--	2	1	3	--
Metal:						
Capacitor grade	--	--	--	--	--	--
Ingots	--	--	18	18	36	--
Oxide	9	--	9	1	10	--
Total	363	--	256	246	502	--

[e]Estimated. -- Zero.
[1]Data may not add to totals shown because of independent rounding.
[2]Goal effective as of December 28, 2001.

Source: Defense National Stockpile Center.

TABLE 4
REPORTED CONSUMPTION, BY END USE, OF FERROCOLUMBIUM AND NICKEL COLUMBIUM IN THE UNITED STATES[1]

(Metric tons, columbium content)

End use	2004	2005
Steel:		
Carbon	1,110	1,390
Stainless and heat-resisting	581 r	562
Full alloy	(2)	(2)
High-strength low alloy	847	464
Electric	(2) r	(2)
Tool	(2)	(2)
Unspecified	--	--
Total	3,060 r	2,950
Superalloys	699 r	1,220
Alloys (excluding alloy steels and superalloys)	(3)	(3)
Miscellaneous and unspecified	(4)	(4)
Grand total	3,760 r	4,170

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Included with "Steel, high-strength low alloy."
[3]Included with "Miscellaneous and unspecified."
[4]Less than ½ unit.

TABLE 5

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

Class	2004 Gross weight (metric tons)	2004 Value (thousands)	2005 Gross weight (metric tons)	2005 Value (thousands)	Principal destinations and sources, in 2005 (gross weight in metric tons and values in thousand dollars)
Exports:[2]					
Columbium:					
Ores and concentrates	16	$108	43	$398	Germany 7, $162; United Kingdom 9, $62; Italy 3, $32; China 9, $17; Japan 3, $11.
Ferrocolumbium	294	2,920	410	4,210	Canada 322, $3,560; Mexico 81, $599; Chile 2, $27; Colombia 4, $11; Peru 1, $7.
Tantalum:					
Synthetic concentrates	6	61	66	156	Germany 2, $70; China 36, $66; Brazil 10, $13.
Ores and concentrates	717	19,300	479	9,140	Kazakhstan 287, $7,340; Brazil 168, $1,260; China 17, $375; Italy 2, $51; Taiwan[3], $32; France 1, $17.
Unwrought, powders	257	152,000	242	112,000	Israel 81, $54,500; Czech Republic 44, $41,700; Germany 38, $5,370; Mexico 33, $5,130; Sweden 23, $2,460; Thailand 1, $1,920; Japan 4, $1,200; China 5, $648; India 3, $497.
Unwrought, alloys and metal	20	2,890	10	2,690	Belgium 4, $1,470; Japan 1, $484; Germany 1, $206; France[3], $183; Canada[3], $57; Mexico[3], $19.
Waste and scrap	321	18,600	447	21,200	United Kingdom 136, $4,150; Germany 54, $3,620; Japan 62, $3,260; Hong Kong 61, $1,120; Belgium 27, $1,050.
Wrought	162	83,400	110	49,000	Israel 19, $11,700; Germany 29, $10,300; France 111, $4,270; United Kingdom 11, $2,940; Thailand 6, $1,990; Canada 1, $245.
Total	XX	279,000	XX	199,000	Israel, $66,200; Czech Republic $41,700; Germany, $19,700; Kazahstan $7,340; United Kingdom $7,160; Mexico $5,730; Japan $4,960; France $4,470; Thailand $3,910.
Imports for consumption:					
Columbium:					
Ores and concentrates	5	41	10	117	United Kingdom 8, $67; China 1, $41; India 1, $7; Japan[3], $4.
Oxide	906	13,900	946	13,400	Brazil 420, $5,260; Estonia 208, $2,380; Germany 60, $2,410; China 104, $1,540; Russia 129, $1,460.
Ferrocolumbium	7,950	69,000	8,360	71,700	Brazil 7,400 $62,000; Canada 851, $7,800; Germany 106, $1,830.
Unwrought, alloys, metal, powder	940	18,500	1,380	26,700	Brazil 782, $13,900; Estonia 68, $2,220; Germany 58, $1,570; Belgium 14, $231; Kazakhstan 3, $204; China 9, $177.
Tantalum:					
Synthetic concentrates	--	--	--	--	All from China.
Ores and concentrates	1,480	58,000	1,250	43,700	Australia 982, $37,840; Canada 268, $5,930; United Kingdom[3], $4.
Unwrought powders	386	98,400	232	63,100	Japan 50, $25,600; China 77, $13,400; Germany 48, $11,600; Thailand 49, $11,300.
Unwrought, alloys and metal	166	19,200	174	24,700	Kazakhstan 89, $12,700; Japan 9, $10,900; China 24, $3,480; Germany 8, $1,730; United Kingdom 5, $433; Hong Kong 6, $404.
Waste and scrap	503	20,500	758	17,500	China 345, $2,570; Japan 101, $2,240; Israel 44, $2,100; Germany 33, $1,540; Hong Kong 28, $1,100; Netherlands 22, $669; Taiwan 10, $171.
Wrought	38	10,000	78	17,100	China 21, $8,290; Kazakhstan 47, $6,990; Canada 1, $419; Japan 6, $594; Germany 1, $321; Austria 1, $159; Russia 1, $103.
Total	XX	307,000	XX	278,000	Brazil $74,100; Japan $39,330; Australia $37,800; China $30,123; Kazakhstan $19,900; Germany $16,900; Thailand $11,270; Canada $9,740.

XX Not applicable. -- Zero.

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

[2]For columbium, data on exports of metal and alloys in unwrought and wrought form, including waste and scrap, are not available; included in nonspecific tariff classification.

[3]Less than ½ unit.

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

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF COLUMBIUM ORES AND CONCENTRATES, BY COUNTRY[1]

	2004		2005	
Country	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Australia	4	$6	--	--
Canada	(2)	4	--	--
China	1	30	1	$41
India	--	--	1	7
Japan	--	--	(2)	4
United Kingdom	--	--	8	67
Total	5	41	10	119

-- Zero.

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

[2]Less than ½ unit.

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

TABLE 7
U.S IMPORTS FOR CONSUMPTION OF TANTALUM ORES AND CONCENTRATES, BY COUNTRY[1]

	2004		2005	
Country	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Australia	1,170	$52,100	982	$37,800
Canada	277	4,570	268	5,930
China	(2)	4	(2)	3
Ethiopia	30	1,240	--	--
Japan	(2)	30	--	--
United Kingdom	1	30	(2)	2
Total	1,480	58,000 r	1,250	43,700

[r]Revised. -- Zero.

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

[2]Less than ½ unit.

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

TABLE 8
PRINCIPAL WORLD COLUMBIUM AND TANTALUM RAW MATERIAL PRODUCERS

Country	Company and/or mine	Material type
Mining of columbium- and tantalum-bearing ores:		
Australia	Sons of Gwalia Ltd. (Greenbushes)	Columbium-tantalum.
Do.	Sons of Gwalia Ltd. (Wodgina)	Tantalum.
Brazil	Cia. Brasileira de Metalurgia e Mineracao (Araxa)	Columbium.
Do.	Cia. de Estanho Minas Brasil[1]	Columbium-tantalum.
Do.	Paranapanema S.A. Mineracao Industria e Construcao (Pitinga)	Do.
Do.	Mineracao Catalao de Goias S.A. (Catalao)	Columbium.
Canada	Cambior Inc. and Mazarin Inc. (Niobec)	Do.
Do.	Tantalum Mining Corp. of Canada Ltd.[2]	Tantalum.
China	Government-owned	Columbium-tantalum.
Production of columbium- and tantalum-bearing tin slags:		
Australia	Sons of Gwalia Ltd. (Greenbushes)	Do.
Brazil	Cia. Industrial Fluminense[1]	Do.
Do.	Mamoré Mineracao e Metalurgia[3]	Do.
Thailand	Thailand Smelting and Refining Co. Ltd.	Do.
Production capacity for columbium- and tantalum-bearing synthetic concentrates, Germany, western states	H.C. Starck GmbH & Co. KG	Do.

[1]A wholly owned subsidiary of Metallurg Inc., New York, NY.
[2]A wholly owned subsidiary of Cabot Corp.
[3]A subsidiary of Paranapanema S.A. Mineracao Indústria e Construcao.

TABLE 9
PRINCIPAL WORLD PRODUCERS OF COLUMBIUM AND TANTALUM PRODUCTS

Country	Company	Products[1]
Austria	Treibacher Industrie AG	Nb and Ta oxide/carbide, FeNb, and NiNb.
Brazil	Cia. Brasileira de Metalurgia e Mineracao	Nb oxide/metal, FeNb, and NiNb.
Do.	Cia. Industrial Fluminense[2]	Nb and Ta oxide.
Do.	Mineracao Catalao de Goias S.A.	FeNb.
Canada	Cambior Inc. and Mazarin Inc.	Do.
Estonia	Silmet	Nb oxide/metal.
Germany, western states	Gesellschaft fur Elektrometallurgie mbH[2]	FeNb and NiNb.
Do.	H.C. Starck GmbH & Co. KG	Nb and Ta oxide/metal/carbide, K-salt, FeNb, NiNb, and Ta capacitor powder.
Japan	Mitsui Mining & Smelting Co.	Nb and Ta oxide/metal/carbide.
Do.	Cabot Supermetals[3]	Ta capacitor powder.
Do.	H.C. Starck-V Tech Ltd.[4]	Do.
Kazakhstan	Ulba Metallurgical	Ta oxide/metal.
Do.	Irtysh Chemical & Metallurgical Works	Nb oxide/metal.
Russia	Solikamsk Magnesium Works	Nb and Ta oxide.
Thailand	H.C. Starck (Thailand) Co. Ltd.[4]	K-salt and Ta metal.
United States	Cabot Supermetals[3]	Nb and Ta oxide/metal, K-salt, and Ta capacitor powder.
Do.	H.C. Starck Inc.[5]	Nb and Ta metal, and Ta capacitor powder.
Do.	Kennametal Inc.	Nb and Ta carbide.
Do.	Reading Alloys Inc.	FeNb and NiNb.
Do.	Wah Chang[6]	Nb metal and FeNb.

[1]Nb, columbium; Ta, tantalum; FeNb, ferrocolumbium; NiNb, nickel columbium; K-salt, potassium fluotantalate; oxide, pentoxide.
[2]A wholly owned subsidiary of Metallurg Inc., New York, NY.
[3]A wholly owned subsidiary of Cabot Corp.
[4]A subsidiary of H.C. Starck GmbH & Co. KG.
[5]Jointly owned by Bayer Corp. and H.C. Starck GmbH & Co. KG.
[6]A subsidiary of Allegheny Technologies Inc.

TABLE 10

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

(Metric tons)

Country[5]	Gross weight[3]					Columbium content[4]					Tantalum content[4]				
	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Australia, columbite-tantalite	2,220	3,100	2,500	2,000	2,000	230	290	230	200	200	660	940	765	730	730
Brazil:															
Pyrochlore	65,000	68,800	69,000	56,100	56,200 [p]	27,300	41,300 [r]	37,000 [r]	34,000 [r]	35,000 [p]	(6) [r]	(6) [r]	(6) [r]	(6) [r]	(6) [p]
Tantalite	750	680	715	720	730 [p]	(6) [r]	(6) [r]	(6) [r]	(6) [r]	(6)	210	190	200	250	250 [p]
Burundi	123 [7]	72 [7]	24 [7]	23 [r, 7]	24	NA	NA	4 [r]	4 [r]	4	32	15	6	6	6
Canada:															
Pyrochlore	7,070	7,410	7,270	7,300 [7]	7,300	3,180	3,330	3,270 [7]	3,450 [7]	3,300 [p]	(6) [r]	(6) [r]	(6) [r]	(6) [r]	(6)
Tantalite	308	232	220	220 [7]	220 [p]	15	12	11 [7]	10 [7]	10 [p]	77	58	55	69 [7]	70 [p]
Congo (Kinshasa), columbite-tantalite	200	100	50	50 [r, 7]	50	60 [r]	30 [r]	25 [r]	25 [r]	25	60	30	25 [r]	25 [r]	25
Ethiopia, tantalite	47 [7]	55 [7]	58 [r, 7]	71 [r, 7]	71	5	6	6	7 [r]	7	28	33 [r]	35	45 [r]	45
Mozambique	27 [7]	47 [7]	189 [7]	712 [7]	281	3 [r]	6 [r]	23 [r]	87 [r]	34	8 [r]	13 [r]	54 [r]	205 [r]	81
Namibia	5	9	23 [r, 7]	10 [r, 7]	5	(6)	(6)	1 [7]	1 [7]	(6)	3	5 [r]	14 [r]	6 [r]	3
Nigeria, columbite-tantalite	610	156 [7]	383 [4]	100 [r, 7]	100	250	65	160	40 [r]	40	30	8	21	5 [r]	5
Rwanda	241 [7]	96 [7]	128 [7]	200	200	76	30	40	63	63	53	20	26	40	40
Uganda	11 [7]	6 [7]	16 [7]	(6) [7]	(6)	5	3 [7]	8	(6) [r]	(6)	3 [7]	2 [7]	4 [7]	(6) [7]	(6)
Zimbabwe	30	481 [7]	231 [7]	14	NA	NA	NA	NA	NA	NA	9	144	69	4	NA
Total	76,600	81,200	80,800	67,500	67,200	31,100	45,100 [r]	40,800 [r]	37,900 [r]	38,700	1,170 [r]	1,460 [r]	1,280	1,390 [r]	1,260

[r]Revised. NA Not available.

[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 July 9, 2006.

[3]Data on gross weight generally have been presented as reported in official sources of the respective countries, divided into concentrates of columbite, tantalite, and pyrochlore where information is available to do so, and reported in groups, such as columbite and tantalite, where it is not.

[4]Unless otherwise specified, data presented for metal content are estimates based on, in most part, reported gross weight and/or pentoxide content.

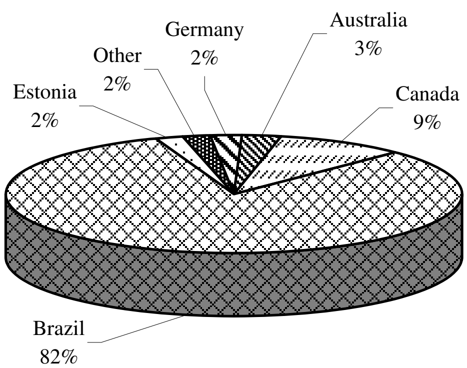
[5]In addition to the countries listed, Bolivia, China, French Guiana, Kazakhstan, and Russia also produce, or are believed to produce, columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[6]Less than ½ unit.

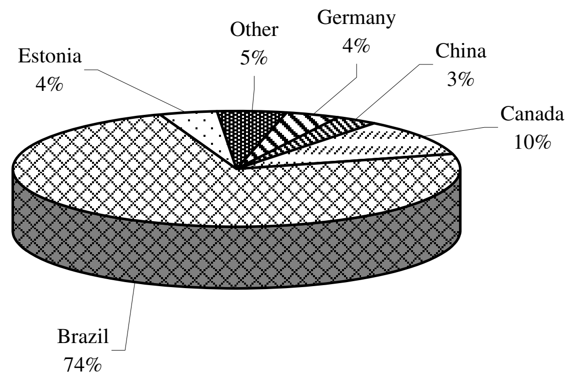
[7]Reported figure.

FIGURE 1
MAJOR SOURCES OF U.S. COLUMBIUM IMPORTS

(Columbium content)[1]



2005

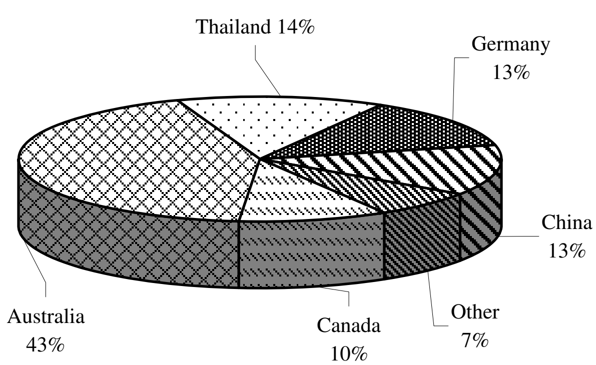


2002-05

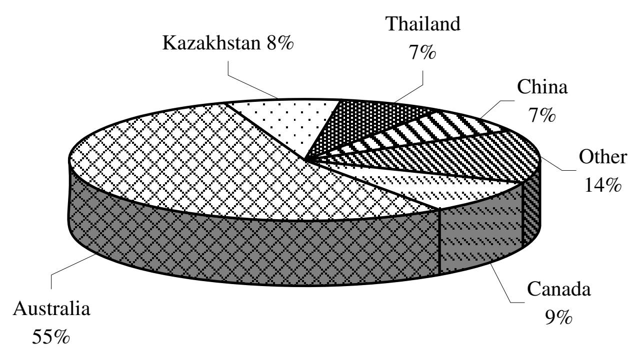
[e]Estimated.

FIGURE 2
MAJOR SOURCES OF U.S. TANTALUM IMPORTS

(Tantalum content)[1]



2005



2002-05

[e]Estimated.