COLUMBIUM (NIOBIUM) AND TANTALUM

By Larry D. Cunningham

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

Tantalum (Ta) is a refractory metal that is ductile, easily fabricated, has a high melting point, is highly resistant to corrosion by acids, and is a good conductor of heat and electricity. Tantalum is also 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.

Domestic columbium and tantalum resources are of low grade. Some are mineralogically complex, and most are not currently commercially recoverable. The last significant mining of columbium and tantalum was during the Korean conflict when increased military demand resulted in columbium and tantalum ore shortages.

The United States continued to be dependent on imports of columbium and tantalum materials, with Brazil remaining the major source for columbium imports and Australia the major source for tantalum imports. The Defense Logistics Agency (DLA) offered and sold selected columbium and tantalum materials from the National Defense Stockpile (NDS). The Generalized System of Preferences (GSP), which expired on May 31, 1997, was renewed on August 5, 1997, and extended to June 30, 1998. Columbium and tantalum price quotations remained relatively stable, with a moderate rise in the price for ferrocolumbium and tantalite ore. Overall reported consumption of columbium in the form of ferrocolumbium and nickel columbium continued to increase, with demand for columbium in superalloys up significantly. Tantalum consumption increased for the year, owing to increased demand from the electronics industry.

Legislation and Government Programs

Summaries of important columbium and tantalum statistics are shown in tables 1 and 2, respectively. To ensure a supply of columbium and tantalum during an emergency, goals for both materials have been established for the NDS. As of September 30, 1997, NDS overall goal for the columbium group was 982 tons, and the overall goal for the tantalum group was 1,050 tons. *(See table 3.)*

During the year, the U.S. Government initiated the sale of columbium and tantalum from the NDS. According to the DLA Annual Materials Plan (AMP) for each of fiscal years (FY) 1997 (October 1, 1996, through September 30, 1997) and FY 1998 (October 1, 1997, through September 30, 1998), the maximum amount of ferrocolumbium that could be sold would be about 91 metric tons of columbium contained in ferrocolumbium. Sales of ferrocolumbium began in March 1997. For FY 1997, the DLA sold about 37 tons of columbium contained in ferrocolumbium valued at about $537,000. Contracts were awarded to H.C. Starck, Inc., Newton, MA; Parkans International, Houston, TX; and Considar, Inc., New York, NY. For FY 1998 (October 1, 1997, through December 31, 1997), the DLA sold about 91 tons of columbium contained in ferrocolumbium valued at about $1.25 million to Considar and H.C. Starck. The sales exhausted DLA's authority for ferrocolumbium disposals under the AMP in FY 1998.

For FY 1997 and FY 1998, the DLA had authority under the AMP to sell 1 ton of tantalum contained in tantalum carbide, 9 tons of tantalum contained in tantalum oxide, and 45 tons of tantalum contained in tantalum minerals. For FY 1997, the DLA sold about 1 ton of tantalum contained in tantalum carbide valued at about $133,000 and about 9 tons of tantalum contained in tantalum oxide valued at about $1.1 million to H.C. Starck. For FY 1998, in October 1997, the DLA sold an additional 1 ton of tantalum contained in tantalum carbide valued at about $131,000 to H.C. Starck and about 9 tons of tantalum contained in tantalum oxide valued at about $1.3 million to Kennametal Inc., Latrobe, PA. There were no sales of tantalum minerals during the year.

Under GSP, the United States grants duty free access to goods from qualifying developing countries and territories. In 1997, U.S. imports for selected columbium and tantalum materials ranged from duty free to 5% ad valorem for most-favored-nation (MFN) status and from duty free to 45% ad valorem for non-MFN status.

The GSP program expired on May 31, 1997. On August 5, 1997, the President signed the Budget Reconciliation Tax Bill of 1997, which contained provisions for the extension of duty-free treatment and the retroactive application for certain liquidations and reliquidations under the GSP. The provisions apply GSP duty-free treatment to eligible articles from designated beneficiary countries that are entered, or withdrawn from warehouse, for consumption on or after August 5, 1997, through June 30, 1998, and for those entries made after May 31, 1997, through August 4, 1997, to which duty-free treatment would have applied, and to refund any duty paid with respect to such entry, provided that a request for liquidation or reliquidation is filed with the Customs Service by February 4, 1998 (U.S. Department of the Treasury, 1997).

Production

Domestic production data for ferrocolumbium are developed by the U.S. Geological Survey from the annual voluntary domestic survey for ferroalloys. However, ferrocolumbium production data for 1997 were incomplete at the time this report was prepared.

Although there was no domestic mineral production of either

columbium or tantalum in 1997, Cabot Corp., Boyertown, PA, was integrated from raw material processing through to the production of columbium and tantalum end products. Shieldalloy Metallurgical Corp., Newfield, NJ, was a producer of ferrocolumbium. H.C. Starck GmbH & Co. KG, with plants in Newton, MA, and Gurnee, IL, was a major supplier of tantalum and columbium products. Reading Alloys Inc., Robesonia, PA, and Wah Chang, a subsidiary of Allegheny Teledyne Inc., Albany, OR, were major producers of high-purity columbium products. Kennametal Inc., Latrobe, PA, was a major supplier of columbium and tantalum carbides. *(See table 9.)*

In April, Metallurg Inc., New York, NY, announced that the company along with its subsidiary, Shieldalloy Metallurgical, had emerged from court protection under Chapter 11 of the U.S. Bankruptcy Code, following completion of an operational and financial restructuring. Metallurg had sought court protection from its creditors in September 1993 (American Metal Market, 1997c; Platt's Metals Week, 1997; Tantalum-Niobium International Study Center, 1997).

Consumption

Overall reported consumption of columbium as ferrocolumbium and nickel columbium rose by more than 10% compared with that in 1996. *(See table 4.)* Consumption of columbium by the steelmaking industry increased by about 8%, with consumption up in all major reported steel end-use categories. Demand for columbium in superalloys increased to about 838 tons from about 654 tons in 1996, reflecting strong demand from the commercial aerospace industry. That portion used in the form of nickel columbium rose to about 490 tons.

Overall consumption of tantalum rose to about 500 tons, aided by the recovery of the U.S. electronics industry. Industry sources indicated that factory sales of tantalum capacitors increased by about 30%, owing to strong demand for tantalum capacitors in electronic products such as portable telephones, pagers, video cameras, and personal computers.

Columbium.—Columbium and niobium are synonymous names for the chemical element with atomic number 41; columbium was the first name given, and niobium was the name officially designated by the International Union of Pure and Applied Chemistry in 1950. The metal conducts heat and electricity relatively 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, principally as an additive to improve the strength and corrosion resistance of steel. Because of its refractory nature, appreciable amounts of columbium in the form of high-purity ferrocolumbium and nickel columbium are used in nickel-, cobalt-, and iron-base superalloys for applications such as jet engine components, rocket subassemblies, and heat-resisting and combustion equipment. Columbium carbide is used in cemented carbides to modify the properties of the cobalt-bonded tungsten carbide-based material. It is usually used with carbides of metals such as tantalum and titanium. Columbium oxide is the intermediate product used in the manufacture of high-purity ferrocolumbium, nickel columbium, columbium metal, and columbium carbide.

Tantalum.—The major end use for tantalum, as tantalum metal powder, is in the production of electronic components, mainly tantalum capacitors. Applications for tantalum capacitors include computers, communication systems, instruments and controls for aircraft, missiles, ships, and weapon systems. The tantalum capacitor exhibits reliable performance and combines compactness and high efficiency with good shelf-life. 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 employed in aerospace structures and jet engine components. Tantalum carbide, used mostly in mixtures with carbides of such metals as columbium, titanium, and tungsten, is used in cemented-carbide cutting tools, wear-resistant parts, farm tools, and turning and boring tools. Because of tantalum's excellent corrosion-resistant properties, tantalum mill and fabricated products are used in the chemical industry in applications such as heat exchangers, evaporators, condensers, pumps, and liners for reactors and tanks.

Prices

A published price for pyrochlore concentrates produced in Brazil and Canada was not available. 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 Platt's Metals Week price for regular-grade ferrocolumbium, produced from pyrochlore concentrates and quoted at $6.58 per pound of contained columbium since June 1989, was discontinued at yearend 1996. The American Metal Market published price for regular-grade ferrocolumbium, quoted since June 1989 at $6.58 per pound of contained columbium, rose to a range of $6.75 to $7 per pound in September, where it remained through December.

The Metal Bulletin price for columbite ore, on the basis of a minimum 65% contained columbium oxide (Nb_2O_5) and tantalum oxide (Ta_2O_5), remained unchanged at a range of $2.80 to $3.20 per pound. The Metals Week published price for the following columbium products were all discontinued at yearend 1996: columbium oxide, $8.17 per pound of oxide; high-purity ferrocolumbium containing 62% to 68% columbium, $18.50 per pound of contained columbium; nickel columbium, $20.50 per pound of contained columbium; and columbium metal, a range of $30 to $50. The American Metal Market published price for high-purity ferrocolumbium, quoted since June 1989 at a range of $17 to $17.50, rose to a range of $17.50 to $18 in September, where it remained through December.

The Metals Week spot price for tantalite ore, on the basis of contained Ta_2O_5, f.o.b. U.S. ports, quoted at a range of $27 to $28.50 since October 1995, rose to a range of $32 to $34 per pound in October 1997, where it remained through December. For the year, the Metal Bulletin published price for tantalite was at a range of $28 to $31.50 per pound of contained Ta_2O_5, and the price for tantalite produced at the Greenbushes Mine in Australia, on the basis of 40% contained Ta_2O_5, was $40 per pound. The most recent industry source on tantalum prices indicated that the average selling prices for some tantalum products were as follows (per pound of contained tantalum): powder, $100 to $180; wire, $170 to $250; and sheet, $100 to $150. Tantalum oxide was selling at an average of $40 to $90 per pound of oxide, and the average selling price for tantalum carbide was $45 to $60 per pound.

Foreign Trade

Data for exports and imports are summarized in table 5. Net trade for columbium and tantalum continued at a deficit, with imports exceeding exports by the highest level since 1981. Overall trade value for exports increased by about 18%, with total volume down by about 10%. The volume of ferrocolumbium exports continued to be affected by the diminished availability of Canadian pyrochlore concentrates for domestic steelmaking-grade ferrocolumbium production. For imports, overall trade value was up by about 16% with total volume up by more than 30%. Steelmaking-grade ferrocolumbium capacity developed in Canada in late 1994 contributed to the rise in ferrocolumbium imports.

Imports for consumption of columbium ores and concentrates were down by more than 40%, with the continued decrease in the volume of imports from Canada. *(See table 6.)* Imports at an average grade of approximately 53% Nb_2O_5 and 16% Ta_2O_5 were estimated to contain about 50 tons of columbium and about 20 tons of tantalum.

Imports for consumption of tantalum ores and concentrates were down by about 20%, with imports from Australia accounting for more than 60% of total quantity and almost 70% of total value. *(See table 7.)* Imports at an average grade of approximately 35% Ta_2O_5 and 27% Nb_2O_5 were estimated to contain about 260 tons of tantalum and about 170 tons of columbium.

Imports for consumption of synthetic tantalum-columbium concentrates totaled 27 tons valued at $908,000 compared with 30 tons valued at $1.1 million in 1996. These figures are not included in the salient statistics data.

The schedule of tariffs applied during 1997 to U.S. imports of selected columbium and tantalum materials is found in the U.S. International Trade Commission's (USITC's) 1997 Harmonized Tariff Schedule of the United States, USITC Publication 3001. Brazil continued as the major source for U.S. columbium imports, accounting for about 75% of the total, and Australia remained the major source for U.S. tantalum imports, accounting for about 38% of the total. *(See figures 1 and 2.)*

World Review

Industry Structure.—Principal world columbium and tantalum raw material and product producers are shown in tables 8 and 9, respectively. Annual world production of columbium and tantalum mineral concentrates, by country, is given in table 10. Brazil and Canada were the major producers of columbium mineral concentrates, while tantalum mineral concentrates were produced mainly in Australia, Brazil, and Canada.

Australia.—For its FY ending June 30, 1997, Gwalia Consolidated Ltd., reported that tantalum oxide produced in tantalum concentrates at its Greenbushes Mine, southwest Western Australia, and Wodgina Mine, northwest Western Australia, totaled about 304 tons. Greenbushes production was down from that of the previous year, reflecting the mining of a lower grade of ore. For the same period, sales of tantalum oxide in concentrate totaled about 313 tons, representing about 56% of Gwalia's total sales revenues. Gwalia reportedly supplies about 50% of all tantalum units produced from primary sources worldwide. The company has sold about 1,020 tons of tantalite concentrates, all of its budgeted production in calendar years 1997 to 2000, under long-term contracts. The sales equate to total gross revenues of about $130 million. Completion of the first stage in a progressive program to increase annual ore throughput capacity at Wodgina resulted in annual production capacity of up to about 90 tons of tantalum oxide contained in concentrate. Gwalia's new growth initiatives included a prefeasibility study to assess further expansion at Wodgina that would increase annual tantalum oxide production capacity to almost 140 tons. Tantalum reserves at Wodgina totaled about 1,460 tons of contained tantalum oxide, while reserves at Greenbushes totaled about 5,640 tons of contained tantalum oxide (Gwalia Consolidated Ltd., 1997).

Brazil.—In 1997, Brazil's production of columbium oxide in concentrates increased to about 25,900 tons — 22,400 tons produced by Cia. Brasileira de Metalurgia e Mineracao (CBMM) and 3,500 tons produced by Mineracao Catalao de Goias S.A. CBMM, the world's largest columbium producer, was reported to have shipped about 18,800 tons of ferrocolumbium, 480 tons of vacuum-grade alloys, about 1,390 tons of columbium oxide, and 31 tons of columbium metal. Brazil's consumption of columbium, based on contained columbium oxide, totaled 1,320 tons, compared with 930 tons in 1996 (The TEX Report, 1998b). CBMM announced that the company would raise its annual ferrocolumbium production capacity from 23,000 tons to 30,000 tons by yearend. The expansion is the company's first since 1980 and is aimed at maintaining the stability of world supply and pricing of ferrocolumbium. The expansion will require only a small investment and will be accomplished through modification to the production flow. CBMM also plans to invest $2 million to start producing about 150 tons per year of high-purity columbium oxide for use in the optical glass industry (Metal Bulletin, 1997).

In October, Companhia de Pesquisa de Recursos Minerais (CPRM), Brazil's state-controlled geological agency announced that the tender for the extraction rights to the large columbium ore reserve in western Amazonas state had been postponed until February 1998. The tender was postponed by CPRM to give applicable government agencies time to address environmental and legal concerns. Under terms of the tender, the successful bidder must pay about US$550,000 in four installments over a 1-year period plus a 3% royalty on all sales from the reserve. The 2.9-billion-ton reserve, grading about 2.8% Nb_2O_5, is in the region bordering Venezuela (American Metal Market, 1997a; Mining Journal, 1997).

Canada.—Production of columbium oxide contained in pyrochlore concentrate at the Niobec Mine near Chicoutimi, Quebec, was about 3,280 tons. Niobec is a 50-50 joint venture between Teck Corp., operator, and Cambior Inc., product marketing. Columbium contained in ferrocolumbium production was about 2,190 tons, with a pyrochlore-to-ferrocolumbium converter recovery of 95.9%. Ore milled increased to 830,000 tons, as the mill operated on the average of about 2,280 tons per day of ore. Average recovery decreased to 57.8% with Nb_2O_5 grade of concentrate at 68%. Teck reported that Niobec ore reserves are sufficient for another 14 years of mine life. Niobec contributed $8.4 million to Teck's operating profit in 1997 compared with $7.2 million in 1996. In 1998, Niobec is expected to produce about 2,270 tons of ferrocolumbium. Capital expenditures are expected to increase to $9 million, with $8 million to be utilized for deepening the mine shaft and developing a lower ore block (Cambior Inc., 1997; Teck Corp., 1997).

Since midyear 1992, tantalum mining at the Bernic Lake, Manitoba, tantalum operation has remained suspended. However, about 66 tons of tantalum oxide contained in concentrate was produced from tailings retreatment in 1997 compared with about 67

tons in 1996.

Montreal-based Niocan Inc. initiated a feasibility study for development of its columbium property in the OKA carbonatite complex 30 kilometers northwest of Montreal. Pyrochlore mineralization at the property reportedly contains an average of about 0.50% Nb_2O_5. Preliminary evaluation indicated that an investment of $50 million would be required to bring the property into production. If the feasibility study is favorable, Niocan hopes to begin mine construction and development in the spring of 1998, with production startup in 1999 (The Northern Miner, 1997a; The Northern Miner, 1997b).

Avalon Ventures Ltd., Toronto, announced that diamond drilling at its Separation Rapids rare metals pegmatite property indicate an economic deposit of cesium, lithium, rubidium, and tantalum. The property is 60 kilometers north of Kenora in Northwestern Ontario. Ore sampled from the property assayed 0.08% Ta_2O_5. Work in 1997 included detailed mapping, channel sampling, magnetic survey, and a shallow diamond drilling program. A market study and a metallurgical scoping study to determine the recoverability of the rare metals identified was planned. Program costs totaled approximately Canadian $600,000 (American Metal Market, 1997d; Skillings Mining Review, 1997).

Japan.—Japan's demand for columbium, contained columbium oxide, was 5,950 tons compared with 4,800 tons in 1996. Ferrocolumbium consumption in steelmaking totaled about 5,030 tons compared with about 5,130 tons in 1996. However, domestic production of ferrocolumbium remained idle. Ferrocolumbium imports totaled about 4,980 tons compared with about 4,760 tons in 1996. Brazil continued as the major source for ferrocolumbium, supplying about 90% of total imports (Roskill's Letter from Japan, 1998a; The TEX Report, 1998a; The TEX Report, 1998b).

Japan's demand for tantalum, in the form of powder, compounds, and tantalum products, was about 334 tons compared with about 322 tons in 1996. Japanese imports of tantalum products (inclusive of ingots and powders) totaled about 68 tons compared with about 92 tons in 1996. Japan's production of tantalum capacitors was about 5.6 billion units compared with about 5.5 billion units in 1996. Japan's exports of tantalum capacitors totaled about 2.1 billion units compared with about 1.9 billion units in 1996 (Roskill's Letter from Japan, 1998b).

Thailand.—A $9.2 million expansion was planned for the manufacturing facilities of H.C. Starck (Thailand) Co., Ltd., Map Ta Phut, a subsidiary of H.C. Starck GmbH & Co. KG, Goslar, Germany. The facility processes tantalum source materials and produces potassium fluotantalate and tantalum metal powder. The expansion involves upgrading manufacturing equipment in Thailand to standards of Starck's tantalum facilities in Germany and Newton, MA. Starck acquired a majority holding in the Thailand facility in 1996 (American Metal Market, 1997b).

Outlook

Columbium.—The principal use for columbium remains as an additive in steelmaking, which annually accounts for around 80% of reported consumption in the United States. The trend of columbium demand, domestically and globally, will continue to follow closely that of steel production. The reader is referred to the outlook section of the Iron and Steel Annual Mineral Industry Surveys for discussion on the outlook for the steel industry. The outlook for columbium also will be dependent on the performance of the aerospace industry and use of columbium-bearing alloys in it. In 1997, columbium consumption in the production of superalloys increased by almost 30% compared with that of 1996. The Aerospace Industries Association forecast that U.S. aerospace sales will probably reach about $145 billion in 1998. This would be a new high, in current dollars, and was based on projected increased sales to the civil aircraft sector, space business, and related products and services. However, the gains would be offset by modest declines in the missiles and military aircraft sector, with overall U.S. government business remaining flat. The aerospace industry is at the transition point where the market is shifting from a government-dominated business to one driven primarily by the commercial sector (Aerospace Industries Association Update, 1998). The majority of U.S. demand for columbium units will continue to be met by imports.

Tantalum.—In 1997, U.S. apparent consumption of tantalum totaled about 500 tons compared with about 490 tons in 1996. About 60% of the tantalum consumed was used to produce electronic components, mainly tantalum capacitors. Worldwide consumption of tantalum capacitors is expected to increase to about 25 billion units by the year 2000, with tantalum consumption in this sector at around 1,000 tons. However, the annual per-unit requirement of tantalum powder and wire for tantalum capacitors is expected to decline. Future tantalum demand in the cemented carbide sector is expected to grow modestly and will be dependent on metal cutting activities. The outlook for tantalum in superalloys, mainly in jet engine components, is favorable. The overall trend is for increased tantalum consumption.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT COLUMBIUM STATISTICS 1/

(Metric tons of columbium content unless otherwise specified)

	1993	1994	1995	1996	1997
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	--	--
Releases from Government excesses	--	--	--	--	--
Production of ferrocolumbium	NA	NA	NA	NA	NA
Exports: Columbium metal, compounds, alloys (gross weight)	NA	NA	NA	NA	NA
Imports for consumption:					
Mineral concentrates e/	1,210	1,480	615	285	220
Columbium metal and columbium-bearing alloys e/	111	171	257	322	423
Ferrocolumbium e/	2,190	2,590	3,580	2,970	4,260
Tin slag	NA	NA	NA	NA	NA
Consumption:					
Raw materials	NA	NA	NA	NA	NA
Ferrocolumbium and nickel columbium e/	2,470	2,750	2,900	3,370 r/	3,780
Apparent e/	3,500	3,700	3,800	3,800	3,900
Prices:					
Columbite, dollars per pound 2/	2.67	2.60	2.97	3.00	3.00
Pyrochlore, dollars per pound 3/	2.75	NA	NA	NA	NA
World: Production of columbium-tantalum concentrates e/	12,400	15,700 r/	17,700 r/	20,200 r/	20,600

e/ Estimated. r/ Revised. NA Not available.

1/ Data are rounded to three significant digits, except prices.

2/ Average value, contained pentoxides for material having a columbium pentoxide to tantalum pentoxide ratio of 10 to 1.

3/ Average value, contained pentoxide.

TABLE 2
SALIENT TANTALUM STATISTICS

(Metric tons of tantalum content unless otherwise specified)

	1993	1994	1995	1996	1997
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	--	--
Releases from Government excesses	--	--	--	--	--
Exports:					
Tantalum ores and concentrates (gross weight) 1/	11	23	1	53	91
Tantalum metal, compounds, alloys (gross weight)	235	242	281	342	396
Tantalum and tantalum alloy powder (gross weight)	57	46	41	26	58
Imports for consumption:					
Mineral concentrates e/	390	310	300	360	280
Tantalum metal and tantalum-bearing alloys 2/	67	73	181	203	187
Tin slag	NA	NA	NA	NA	NA
Consumption:					
Raw materials	NA	NA	NA	NA	NA
Apparent e/	410	430	515	490	500
Prices:					
Tantalite, dollars per pound 3/	26.41	26.24	26.98	27.75	28.76
World: Production of columbium-tantalum concentrates e/	292 r/	333	360 r/	388 r/	413

e/ Estimated. r/ Revised. NA Not available.

1/ Includes reexports.

2/ Exclusive of waste and scrap.

3/ Average value, contained tantalum pentoxides.

TABLE 3
COLUMBIUM AND TANTALUM MATERIALS IN GOVERNMENT
INVENTORIES AS OF DECEMBER 31, 1997 1/

(Metric tons of columbium or tantalum content)

Material	Stockpile goals	Disposal authority	National Defense Stockpile inventory			
			Uncommitted			
			Stockpile-grade	Nonstockpile-grade	Total	Committed
Columbium:						
Concentrates	--	--	444	343	786	--
Carbide powder	--	--	10	--	10	--
Ferrocolumbium	--	296	261	148	409	90
Metal ingots	--	--	73	--	73	--
Total	982 2/	296	788	490	1,280	90
Tantalum:						
Minerals	--	340	681	454	1,140	--
Carbide powder	--	1	11	--	11	--
Metal:						
Capacitor grade	--	--	73	(3/)	73	--
Ingots	--	--	111	--	111	--
Oxide	--	--	56	--	56	--
Total	1,050 2/	341	932	454	1,390	--

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Overall goals for the columbium and tantalum groups as of September 30, 1997.
3/ About 60 kilograms.

Source: Defense Logistics Agency, Defense National Stockpile Center.

TABLE 4
REPORTED CONSUMPTION, BY END USE, AND INDUSTRY STOCKS OF
FERROCOLUMBIUM AND NICKEL COLUMBIUM
IN THE UNITED STATES 1/

(Metric tons of contained columbium)

End use	1996	1997
Steel:		
Carbon	1,250 r/	1,360
Stainless and heat-resisting	403 r/	473
Full alloy	(2/)	(2/)
High-strength low-alloy	1,040 r/	1,080
Electric	--	--
Tool	(3/)	(3/)
Unspecified	7	21
Total	2,710 r/	2,930
Superalloys	654 r/	838
Alloys (excluding alloy steels and superalloys)	(4/)	(4/)
Miscellaneous and unspecified	7	9
Total consumption	3,370 r/	3,780
Stocks, Dec. 31:		
Consumer	NA	NA
Producer 5/	NA	NA
Total stocks	NA	NA

r/ Revised. NA Not available.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Included with "Steel: High-strength low alloy."
3/ Included with "Steel: Unspecified."
4/ Included with "Miscellaneous and unspecified."
5/ Ferrocolumbium only.

TABLE 5
U.S. FOREIGN TRADE IN COLUMBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS 1/

(Metric tons, gross weight, and thousand dollars)

Class	1996 Quantity	1996 Value	1997 Quantity	1997 Value	Principal destinations and sources, 1997
Exports: 2/					
Columbium:					
Ores and concentrates	11	185	32	349	Hong Kong 17, $148; Panama 11, $106; Korea, Republic of 1, $63; Canada (3/), $1 Gemany 1, $9; Brazil 1, $6.
Ferrocolumbium	254	1,490	59	588	Germany 20, $219; Canada 23, $170; Brazil 8, $125; Mexico 8, $74.
Tantalum:					
Synthetic concentrates	38	192	14	126	Russia 7, $55; Finland 7, $55; Singapore (3/), $9; Japan (3/), $5; Mexico (3/), $3.
Ores and concentrates	53	572	91	842	Brazil 71, $512; China 15, $153; Netherlands 1, $78; Japan 1, $50; Korea, Republic of 2, $27; Hong Kong (3/), $22.
Unwrought and waste and scrap	152	7,420	208	8,220	Germany 30, $2,570; China 95, $2,330; United Kingdom 10, $1,620; Hong Kong 55, $1,130; Japan 17, $494; Australia (3/), $39.
Unwrought powders	26	7,860	58	17,100	Israel 25, $8,960; Germany 17, $4,910; Japan 5, $1,760; Austria 8, $772; United Kingdom 1, $521; Portugal 1, $160.
Unwrought alloys and metal	91	24,900	112	29,200	Israel 67, $15,200; United Kingdom 19, $7,710; Taiwan 12, $3,300; France 7, $911 Germany 2, $826; Barbados 2, $561.
Wrought	99	32,100	76	31,700	Japan 30, $11,700; Germany 16, $7,110; United Kingdom 13, $6,430; France 4, $2,040; Singapore 3, $1,230; Canada 5, $643.
Total	XX	74,700	XX	88,200	Israel $24,200; United Kingdom $16,300; Germany $15,600; Japan $14,400; Taiwan $3,460; France $2,950; China $2,610.
Imports for consumption:					
Columbium:					
Ores and concentrates	224	1,700	129	884	Nigeria 82, $451; Russia 33, $335; Canada 11, $68; China 2, $31.
Oxide	901	16,300	1,750	30,700	Brazil 1,280, $20,400; Germany 179, $6,720; Russia 243, $2,730; China 12, $311; Estonia 16, $260; Finland 11, $109.
Ferrocolumbium	4,570	42,100	6,550	59,600	Brazil 5,420, $47,900; Canada 998, $10,500; France 133, $1,220; China (3/), $8.
Unwrought alloys, metal, and powder	322	8,310	423	10,400	Germany 162, $3,650; Brazil 157, $3,480; Kazakstan 51, $1,830; Belgium 35, $733; Estonia 9, $330; Lithuania 1, $196.
Tantalum:					
Synthetic concentrates	30	1,090	27	908	All from China.
Ores and concentrates	1,130	26,400	907	21,600	Australia 570, $14,600; Ethiopia 25, $1,520; Brazil 115, $1,470; Thailand 56, $1,270; Rwanda 58, $984; Nigeria 21, $776.
Unwrought waste and scrap	279	22,500	213	17,000	Japan 39, $3,910; United Kingdom 28, $2,480; Germany 19, $2,460; Lithuania 19, $2,170; China 17, $1,450; Thailand 11, $1,170.
Unwrought powders	125	30,000	117	32,700	Japan 34, $13,500; Thailand 38, $9,270; China 37, $9,010; Germany 6, $787; Kazakstan 1, $136; Russia (3/), $15.
Unwrought alloys and metal	67	11,000	46	8,320	Kazakstan 16, $2,410; China 12, $2,310; Germany 9, $1,470; France 5, $1,120; Japan 2, $563; Austria (3/), $216.
Wrought	11	2,820	24	6,190	China 16, $3,730; Austria 2, $1,050; United Kingdom 2, $668; Japan (3/), $303; Kazakstan 2, $296; Switzerland (3/), $64.
Total	XX	162,000	XX	188,000	Brazil $73,300; Japan $18,300; China $17,900; Germany $15,100; Australia $14,600; Thailand $11,700; Canada $10,600.

XX Not applicable.

1/ Data are rounded to 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 1/2 unit.

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

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

(Metric tons and thousand dollars)

Country	1996		1997	
	Gross weight	Value	Gross weight	Value
Canada	38	201	11	68
China	1	14	2	31
Germany 2/	(3/)	13	--	--
Italy 2/	(3/)	14	--	--
Japan 2/	(3/)	2	--	--
Nigeria	93	513	82	451
Russia	92	921	33	335
United Kingdom 2/	(3/)	19	--	--
Total	224	1,700	129	884

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Presumably country of transshipment rather than original source.
3/ Less than 1/2 unit.

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

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

(Metric tons and thousand dollars)

Country	1996		1997	
	Gross weight	Value	Gross weight	Value
Australia	593	14,900	570	14,600
Austria 2/	--	--	1	103
Belgium 2/	2	106	--	--
Bolivia	--	--	2	83
Brazil	134	2,280	115	1,470
Burundi	60	1,190	--	--
China	23	735	--	--
Congo (Kinshasa) 3/	13	305	51	600
Ethiopia	70	2,910	25	1,520
France 2/	--	--	6	124
French Guiana	--	--	(4/)	6
Germany 2/	1	3	--	--
Ivory Coast 2/	--	--	1	42
Japan 2/	(4/)	7	(4/)	4
Nigeria	19	699	21	776
Russia	79	872	--	--
Rwanda	71	1,260	58	984
Spain	3	77	--	--
Sri Lanka	4	90	--	--
Sweden 2/	--	--	1	8
Thailand	60	997	56	1,270
Total	1,130	26,400	907	21,600

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Presumably country of transshipment rather than original source.
3/ Formerly Zaire.
4/ Less than 1/2 unit.

Sources: Bureau of the Census 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	Gwalia Consolidated Ltd. (Greenbushes)	Columbium-tantalum.
	Gwalia Consolidated Ltd. (Wodgina)	Tantalum.
Brazil	Cia. Brasileira de Metalurgia e Mineracao (CBMM) (Araxa)	Columbium.
	Cia. de Estanho Minas Brasil (MIBRA) 1/	Columbium-tantalum.
	Paranapanema S.A. Mineracao Indústria e Construcao (Pitinga)	Columbium-tantalum.
	Mineracao Catalao de Goias S.A. (Catalao)	Columbium.
Canada	Cambior Inc., and Teck Corp. (Niobec)	Columbium.
	Tantalum Mining Corp. of Canada Ltd. (Tanco) 2/	Tantalum.
China	Government-owned	Columbium-tantalum.
Production of columbium- and tantalum-bearing tin slags:		
Australia	Gwalia Consolidated Ltd. (Greenbushes)	
Brazil	Cia. Industrial Fluminense 1/	
	Mamoré Mineracao e Metalurgia 3/	
Thailand	Thailand Smelting and Refining Co. Ltd. (Thaisarco)	
Production of columbium- and tantalum-bearing synthetic concentrates:		
Germany: Western states	Gesellschaft Für Elektrometallurgie mbH (GFE) 1/	
	H.C. Starck GmbH & Co. KG.	

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 Chemische Werke AG	Nb and Ta oxide/carbide, FeNb, NiNb.
Brazil	Cia. Brasileira de Metalurgia e Mineracao (CBMM)	Nb oxide/metal, FeNb, NiNb.
	Cia. Industrial Fluminense 2/	Nb and Ta oxide.
	Mineracao Catalao de Goias S.A. (Catalao)	FeNb.
Canada	Cambior Inc., and Teck Corp. (Niobec)	FeNb.
Estonia	Silmet	Nb oxide/metal.
Germany: Western states	Gesellschaft Fur Elektrometallurgie mbH (GFE) 2/	FeNb, NiNb.
	H.C. Starck GmbH & Co. KG	Nb and Ta oxide/metal/carbide, K-salt, FeNb, NiNb, Ta capacitor powder.
Japan	Mitsui Mining & Smelting Co.	Nb and Ta oxide/metal/carbide.
	Showa Cabot Supermetals 3/	Ta capacitor powder.
	H.C. Starck-V Tech Ltd. 4/	Ta capacitor powder.
Kazakstan	Ulba Metallurgical	Ta oxide/metal.
	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, Ta metal.
United States	Cabot Corp.	Nb and Ta oxide/metal, K-Salt, FeNb, NiNb, Ta capacitor powder.
	H.C. Starck Inc. 5/	Nb and Ta metal, Ta capacitor powder.
	Kennametal, Inc.	Nb and Ta carbide.
	Reading Alloys, Inc.	FeNb, NiNb.
	Shieldalloy Metallurgical Corp. 2/	FeNb, NiNb.
	Wah Chang 6/	Nb oxide/metal, FeNb, NiNb.
	H.C. Starck - TTI, Inc. 4/	Ta capacitor powder.

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.
3/ A joint venture between Showa Denko and Cabot Corp.
4/ A subsidiary of H.C. Starck GmbH & Co. KG.
5/ Jointly owned by Bayer USA and H.C. Starck GmbH & Co. KG.
6/ A subsidiary of Allegheny Teledyne Inc.

TABLE 10
COLUMBIUM AND TANTALUM: ESTIMATED WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY 1/ 2/

(Metric tons)

	Gross weight 3/					Columbium content 4/					Tantalum content 4/				
Country 5/	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
Australia: Columbite-tantalite	495	700	900	920	1,010	50	81	109	112	125	170	238	274	276	302
Brazil:															
Columbite-tantalite	175	175	175	190	190	40	40	40	45	45	50	50	50	55	55
Pyrochlore	22,700	31,400 r/	36,200 r/	42,100 r/	43,100	9,540	13,200 r/	15,200 r/	17,700 r/	18,100	--	--	--	--	--
Canada:															
Pyrochlore	5,320	5,130	5,230	5,160	5,090	2,390	2,310	2,350	2,320	2,290	--	--	--	--	--
Tantalite	100	144	130	220 r/	216	5	7	7	11 r/	11	25	36	33	55 r/	54
Congo (Kinshasa): 6/															
Columbite-tantalite	20	4	4	--	--	5	1	1	--	--	6	1	1	--	--
Pyrochlore	780	--	--	--	--	350	--	--	--	--	--	--	--	--	--
Namibia: Tantalite	--	--	(7/)	--	--	--	--	NA	--	--	--	--	(7/)	--	--
Nigeria: Columbite	40	30	30	30 r/	30	17	13	13	13 r/	13	2	2	2	2 r/	2
Rwanda: Columbite-tantalite	100	10	--	--	--	30	3	--	--	--	22	2	--	--	--
South Africa: Columbite-tantalite	(7/)	--	--	--	--	(7/)	--	--	--	--	(7/)	--	--	--	--
Spain: Tantalite	6	6	--	--	--	NA	NA	--	--	--	2	2	--	--	--
Zimbabwe: Columbite-tantalite	48 r/	7	1 r/	-- r/	--	7 r/	1	(7/) r/	-- r/	--	15 r/	2	(7/) r/	-- r/	--
Total	29,800	37,600 r/	42,700 r/	48,600 r/	49,600	12,400	15,700 r/	17,700 r/	20,200 r/	20,600	292 r/	333	360 r/	388 r/	413

r/ Revised. NA Not available.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Excludes columbium- and tantalum-bearing tin ores and slags. Production of tantalum contained in tin slags was, in metric tons: 1993--132; 1994--NA; 1995--126; 1996--82 and 1997--40 according to data from the Tantalum-Niobium International Study Center. Table includes data available through July 10, 1998.

3/ Data on gross weight generally have been presented as reported in official sources of the respective countries, divided into concentratres 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, Russia, and Zambia also produce, or are believed to produce, columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

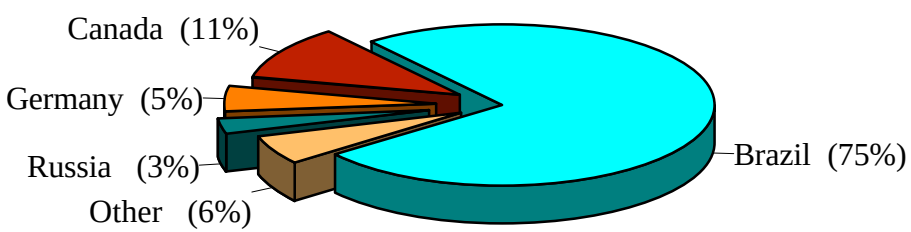
6/ Formerly Zaire.

7/ Less than 1/2 unit.

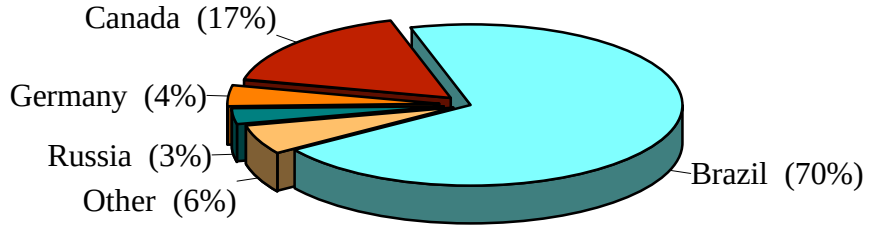
FIGURE 1

MAJOR SOURCES OF U.S. COLUMBIUM IMPORTS

(Columbium Content)



1997

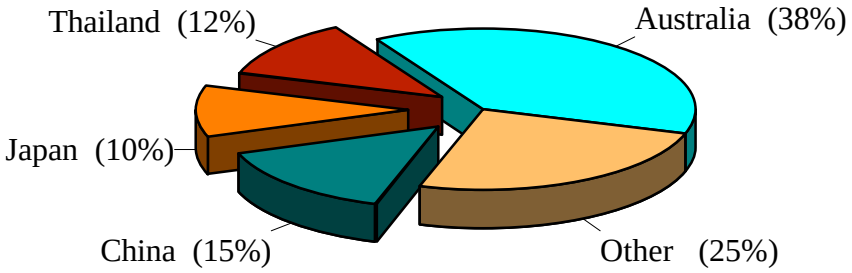


1994 - 1997

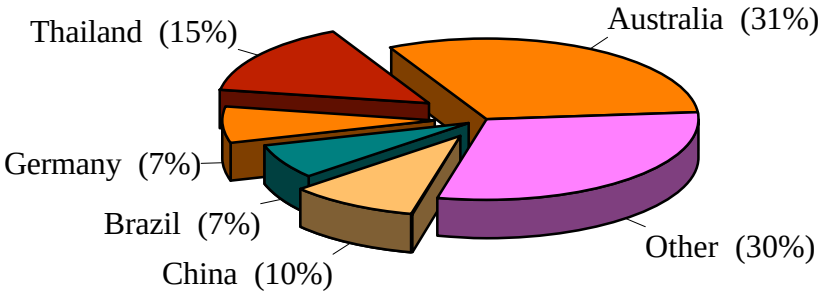
FIGURE 2

MAJOR SOURCES OF U.S. TANTALUM IMPORTS

(Tantalum Content)



1997



1994 - 1997