TANTALUM

By C. Edward Mosheim
Technical Promotion Officer, Tantalum-Niobium International Study Center
40 Rue Washington, 1050 Brussels, Belgium

This year marks the 200th anniversary of the discovery of tantalum in 1802 by Anders Gustaf Ekeberg, a professor at Uppsala University in Uppsala, Sweden. He found this new element by analysis of a tantalite sample from Kimoto, Finland and an yttrotantalite sample from Ytterby, Sweden. He proposed the name tantalum after Tantalus, the son of Zeus in Greek mythology, due to the difficulty of defining the chemical nature and other properties of the element. The metal was first prepared in a relatively pure form in the early 1900s, when filaments of the metal were used in incandescent light bulbs.

The major use for tantalum today is as the anode in a capacitor. It was not until the 1940s that the development of a 'wet' capacitor, utilising a tantalum anode and cathode, created a market for this element. Replacement of the gelled sulphuric acid electrolyte with manganese dioxide led to the 'solid' capacitor. The chip-type capacitor design of the 1980s for tantalum capacitors led to widespread use in computer, telecommunications, automotive, and consumer electronics circuitry. This single application consumes about 60% of all tantalum processed in the world today. Specific tantalum products consumed in capacitor manufacturing are tantalum powder and tantalum wire. Capacitor processing steps also require the use of fabricated furnace hardware of tantalum, such as heat shields, sintering trays, and thermocouple wells.

Tantalum finds use in high-temperature alloys for both air- and sea-based propulsion systems as well as land-based turbines for power conversion. The metal is also used as a sputtering target for the 'laying down' of a very thin film of either tantalum metal or the oxide, and in corrosion-resistant chemical processing equipment. Tantalum chemicals are used in high refractive index optics, and in ceramic capacitor formulations for electronic applications. Medical applications are based on the total inertness of the metal to body fluids, thereby permitting its use in hip and knee replacement fixtures as a 'sponge-like' material that supports bone growth, as well as in plates, screws, surgical clips and as components in pacemaker designs.

The tantalum powder shipments in 2001 show a 44.8% decrease over the quantities shipped in 2000. Total demand for tantalum across all segments decreased 30.1% over 2000. The apparent high growth during 2000 was caused by inflated forecasts for capacitors, in particular in the cellular phone industry, coupled with double and triple ordering. Incursion by speculators fuelled a perceived raw material shortage, followed by the escalation of non-contracted, spot market raw material prices beginning in the third quarter of 2000. A rapid downturn of those same prices occurred at the end of 2000 and into 2001 resulting in the lowest level seen in many years. There was a swift recognition that a real shortage never existed.

The total demand for tantalum in 2001 was 3.44 Mlb of tantalum in all of its forms compared with a total of 4.93 Mlb in 2000.

Production

Tantalum ores are found primarily in Australia, Brazil, Africa, Canada and China.

The largest tantalum mining operations in the world are the Greenbushes and Wodgina mines owned and operated by Sons of Gwalia in Western Australia. Published reports show that the output of tantalite from the combined operation of these two mines was almost 1.8 Mlb of contained Ta_2O_5 in 2001. This was a 37.6% increase in production over 2000. An

expansion of both mining operations to a total of 2.4 Mlb of contained tantalum oxide in concentrates was announced in November 2000 at a cost of A$100 million. These expansions are scheduled for completion during 2002. The output of these two mines is sold under long-term contracts.

The Tanco mine in Manitoba Province, Canada, with an annual capacity of about 150,000 lb of tantalum oxide, has been in operation since about 1970. It is owned by Cabot Performance Materials. Output is expected to continue for about ten years based on current reserves. This is a hardrock underground mine.

The Kenticha mine in Ethiopia continues to be owned and operated by the Ethiopian Government with production of about 120,000 lb/y of tantalum oxide with all output sold by open tender to the highest bidder. Simple gravity-based washing techniques are applied to weathered pegmatite and alluvial ore.

The MIBRA mine, located near São João del Rei in Rondonia State in Brazil, is owned by Metallurg International Resources. Production is expected to be about 100,000 lb/y. This company has facilities at Fluminese in the same area for processing the ore and extracting tantalum oxide, not only from the MIBRA mine, but also from other small local mining operations as well as from tin slag generated by the smelting of tin ores.

Mamoré Mineração e Metalurgia of the Paranapanema Group operates the Pitinga tin mine in the Amazonas region of western Brazil. This mine produces a cassiterite-columbite middling product, which is converted into a ferro-niobium-tantalum alloy. The alloy is further processed as a raw material source for tantalum and niobium. The tantalum content at 5% contributes about 220,000 lb/y to tantalum raw material supplies. Large stockpiles of tin slag at the Mamoré smelter are estimated to contain some 5 Mlb of tantalum oxide at a concentration of 1.6%. Utilisation of this low grade source is not anticipated in the near term because of processing difficulties.

There are numerous mining operations in China, the most notable being the Yichun mine in central China with a capacity of 120,000 lb/y of tantalum oxide. Further expansion of this hardrock mine would require significant capital expenditures and additions of infrastructure. A new mine at Nanping was scheduled to begin production in September 2000 with output gradually increasing to 150,000 lb/y of tantalum oxide over a three-to-five year period. Additional production comes from the Limu tin mine in Altai Region, and from the Ma Ar Kan spodumene mine in Sichuan Province.

Central Africa contains significant tantalum resources. The Democratic Republic of the Congo (DRC), Rwanda, Burundi, Uganda, Nigeria, Namibia and Mozambique have all been producers of tantalum concentrates. The deposits are alluvial and eluvial with production going up and down depending on the price of tantalite. Simple mining and physical concentration operations are conducted in all of these countries, and production could become significant. However, the political unrest and associated financial risk has made investment very unattractive. That condition continues at the present time.

Typical production from this general area of Africa has been estimated at a nominal 300,000 lb/y. The period of high prices for spot concentrate purchases toward the end of 2000 resulted in increased production, particularly in the Democratic Republic of the Congo. With the rapid drop in tantalite prices in late 2000 through the first half of 2001, shipments from this area dropped to low levels.

There have been numerous published reports and investigations by various organisations, including the United Nations, regarding the unauthorised and illegal mining activities in especially the eastern regions of the DRC. Invasion of the national parks in this region by

military and civilian groups and their involvement in these mining activities has destroyed the habitat of endangered elephant and gorilla species. Efforts are being made by the UN to bring a stop to the illegal mining and plundering of these areas through the removal of all military and civilian contingents. The Executive Committee of the Tantalum-Niobium International Study Center (TIC), the Electronics Components, Assemblies & Materials Association (ECA), and other organisations involved with the production and use of tantalum materials, have alerted member companies concerning these issues and support the efforts of the UN and others to bring a stop to these illegal activities.

Tantalum is also found in conjunction with cassiterite, an ore from which tin is extracted by a furnace smelting process. Tantalum values are recovered in the furnace slag. Tin slag containing tantalum is generated primarily in Thailand and Malaysia, with smaller quantities generated in Brazil and Africa. The production of tin slag in southeast Asia generated large quantities of tantalum oxide feed stocks in former times. That industry has remained depressed, resulting in low production of new slag. Most of the current slag availability results from reclamation operations from old slag dumps that are slowly being depleted.

There are numerous tantalum mineralisation prospects being examined for their economic potential and production of tantalum concentrates located in Australia, Canada, Egypt, Saudi Arabia, Greenland, Finland, Bolivia and in various countries in Africa.

Haddington Resources has begun tantalite production in Western Australia at Bald Hill with an annual production of 145,000 lb of tantalum oxide anticipated. The Cattlin Creek deposit is scheduled for production of a similar quantity in 2002. This company also purchased a series of known prospects in the Pilbara region from Australian Tantalum. The Dalgaranga deposit of Tantalum Australia has commenced production annualised at 100,000 lb of tantalum oxide. Additional projects under evaluation by Tantalum Australia include Mt. Deans, Binneringie, and Walwa. Kanowna Lights Ltd has projects under evaluation at Arthur River, Beryl Hill and Pilgangoora.

Additional evaluations in Australia are being undertaken by Quantum Resources on the Cobalark prospect, Galaxy Resources at North Ravensthorpe, and Julia Mines on the Bynoe and Shoobridge projects near Darwin.

Some of the projects identified in Canada are Lilypad Lakes, Raleigh Lakes and East Braintree, in Manitoba (Avalon Ventures Ltd). Plans were announced by this same company for construction of a pilot facility to process material from their Big Whopper project in Ontario with commercial production anticipated during 2004. Additional prospects under evaluation during 2001 in Canada were the Verity and Fir properties in British Columbia (Commerce Resources Corp.), Bluenose property in Nova Scotia (Champlain Resources), Brazil Lake property in Nova Scotia (Champlain Resources and Waseco Resources), MAC property in the Northwest Territories (War Eagle Mining Co.), and the Case project in Ontario (Platinova A/S).

A project in Alaska is the Kougarok deposit on the Seward Peninsula (Chapleau Resources and Navigator Exploration).

Interest in projects in Africa continues. Evaluation of tantalite prospects in Nigeria is being conducted by Columbia River Resources of Vancouver, British Columbia. The Nigerian Mining Corp. is seeking joint venture partners to develop and market its mineral resources, including niobium and tantalum. One of the large deposits under study is the Abu Dabbab tantalite deposit in Egypt by Gippsland Ltd, an Australian mining company. Reserves are currently estimated at over 7 Mlb of tantalum oxide. Rusina Mining has acquired three mining licences in Namibia generally in the same area as the former Tin Tan mine at Nainais.

In Saudi Arabia, Tertiary Minerals plc has been awarded a five-year exclusive exploration licence for what it describes as the "world's largest known tantalum deposit". Data from previous investigations suggest a 2,840 g/t of Nb_2O_5 and 245 g/t Ta_2O_5 content of run-of-mine ore.

Additional deposits are being investigated in Finland (Rosendal by Tertiary Minerals plc), in Greenland (Platinova A/S), in Bolivia (General Minerals), and in China (Xinjiang Western Tantalum Works).

A summary of tantalum raw material production is shown in the following table.

Tantalum Raw Material Production, 1998 - 2001 (Mlb contained tantalum oxide)

	1998	1999	2000	2001
Tantalite, columbite, struverite, others	1.619	2.390	2.594	2.920
Tin Slag, >2% tantalum oxide	0.527	1.717	0.722	0.802
Totals	**2.146**	**4.107**	**3.317**	**3.722**

Source: Tantalum-Niobium International Study Center (TIC)

It should be stated that the above data do not include tantalum raw materials that were purchased by processors from companies that are not members of the Tantalum-Niobium International Study Center. These sources are reported through the category of 'Processor Receipts' which also include the purchase of any tantalum-containing material that is destined for processing through 'repurification' systems. These data are shown in the following table, with tin slags and all tantalum minerals consolidated in one category.

Processor Receipts, 1998 - 2001 (Mlb contained tantalum oxide)

	1998	1999	2000	2001
Tantalite, columbite, struverite, tin slag	2.929	3.216	4.278	5.397
Secondary materials, scrap, Ta_2O_5, K-Salt	0.943	1.202	1.498	2.068
Totals	**3.872**	**4.418**	**5.776**	**7.465**

Source: Tantalum-Niobium International Study Center (TIC)

The Processor Receipts show greater availability of tantalum oxide units for processing than the data on Raw Material Production. These data include mineral concentrate purchased from sales by the Defense National Stockpile Center (DNSC) of the US as well as mineral concentrates purchased from non-TIC members. The DNSC sold a total of approximately 47,100 lb of vacuum-grade tantalum in 2001, as well as an additional 34,000 lb of tantalum powder and 25,000 lb of tantalum oxide. No mineral concentrates were sold.

Consumption

The major processors of tantalum raw materials are H.C. Starck, Cabot Performance Materials, Ningxia Non-ferrous Metals Smelter, Metallurg International Resources, Mitsui Mining and Smelting Co. Ltd., and NAC Kazatomprom. There are also companies in China that are processing ores and slags with conversion into chemicals. The processing companies generally manufacture a variety of chemicals, powder, ingots, and alloys.

The worldwide demand for tantalum powder for capacitor applications has grown at an annualised rate of 18.3% between 1993 and 2000. The year 2001, however, saw a significant reversal of this trend with shipments of tantalum powder falling from almost 3 Mlb.

to 1.65 Mlb. The period from July through December 2001 saw shipments of only 0.44 Mlb. Negative effects were also observed in the mill products segment due to the reduced demand for tantalum wire and sinter furnace components. The other market segments were not affected by the downturn in electronics.

The following table shows the breakdown of processor shipments for the various forms of tantalum.

Tantalum Product Shipments, 1998 - 2001 (Mlb contained tantalum)

	1998	1999	2000	2001
Ta_2O_5, K_2TaF_7, Chemicals	0.352	0.248	0.324	0.378
Tantalum Ingot	0.159	0.320	0.282	0.307
Carbides	0.309	0.281	0.387	0.436
Powder/Anodes	1.753	2.234	2.997	1.654
Mill Products	0.498	0.566	0.729	0.476
Metallurgical Powder, Unwrought Metal & Scrap,	0.186	0.178	0.208	0.191
Total	**3.259**	**3.827**	**4.927**	**3.442**

Source: Tantalum-Niobium International Study Center (TIC)

The tantalum powder shipments in 2001 are 48.1% of the total with mill products reporting as 13.8% of the 3.44 Mlb in all categories. Approximately 50% of the mill-products category is estimated to be tantalum wire, with most of that quantity being consumed in capacitor manufacturing.

Pricing

Tantalum-bearing materials are not traded on the London Metal Exchange. Also, there are no published prices for tantalum metal or tantalum chemicals. The only pricing information that is published is a reference to tantalite mineral concentrates in the Metal Bulletin. The Tantalum-Niobium International Study Center has no knowledge or comment concerning the accuracy of these published figures.

Tantalum mineral concentrates are sold on a price per pound of contained tantalum oxide content, not on the weight of concentrate itself. The price per pound of contained tantalum oxide is influenced by the tantalum oxide concentration, with lower grades sold at a lower price per pound of tantalum oxide than high content grades.

The larger processors of tantalum-bearing materials generally purchase a significant quantity of their requirements by negotiated long-term contracts with those companies that are producing such material on a continuing basis. Additional material is purchased by spot contracts from mining areas where production of the mineral concentrate is intermittent or offered via periodic tender, with the sale going to the highest bidder.

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. Specifications and their influence on processing requirements, and the volume of a specific product all influence the prices negotiated between buyer and seller.