TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN ISSUE No. 17 MARCH 1979 FIRST QUARTER

T.I.C. Activities

The Eleventh General Assembly of the T.I.C. will be held in Perth, Western Australia, in order to afford to members the opportunity of visiting the operations of Greenbushes Tin N.L., the Australian member of the T.I.C.

The General Assembly is scheduled to convene at 9.30 a.m. on Monday, May 14th, in the Convention Room of the Sheraton Hotel in which the visiting participants will be accommodated. The regular semi-annual Assembly will be followed by a Seminar during which three papers will be presented covering the tantalum raw material supply. At this time, the papers are expected to cover
— The Australian tantalum mining industry.
— The tantalum supply from southeast Asia.
— The worldwide tantalum mineral prospects.

On Tuesday, May 15th, the visit will be made to Greenbushes Tin operations with departure from the Sheraton Hotel at 8.00 a.m. by bus for the trip of about 250 kilometers arriving at the mine town at about 11.00 a.m. After an on-site description of the operations, and luncheon, there will be conducted tours of the mine and processing plant.

Afterwards there will be two alternative possibilities. One group of participants will spend the night at the Lighthouse Inn in Bunbury, a coastal town north of Greenbushes, and return to Perth the following morning for tours of the city. A second group will return to Perth on Tuesday evening to be ready for an early departure on the morning of Wednesday, May 16th, to Kalgoorlie for the « Goldfields Tour ». Kalgoorlie is about 600 kilometers east of Perth and is the center of gold and nickel mining in Western Australia. The trip will be made by air.

The visit will occur in the late autumn season. Temperatures could range from a low of 10 °C (50 °F) to a high of 18 °C (65 °F). Some rain may be expected and participants are advised to bring some form of rain apparel.

The General Assembly, the Seminar and the tour of the Greenbushes Tin operations will be limited to T.I.C. members and their invited guests. Data concerning arrangements for attending have been sent to each member with the request that confirmation of attendance be sent to the T.I.C. Secretary by February 14th.

T.I.C. ELEVENTH GENERAL ASSEMBLY

The Eleventh General Assembly of the T.I.C. will be convened at 9.30 a.m. on Monday, May 14, 1979 in the Sheraton Hotel in Perth, Western Australia.

The agenda for the meeting will be :

1. Opening address by the President.
2. New membership.
3. Report of the Executive Committee on 1978 activities.
4. Approval of 1978 accounts.
5. Budget for 1979.
6. Reports on
— Quarterly Bulletin
— Publication of the 1978 Symposium Proceedings.
7. Statutory elections.
8. Other matters.

The formal meeting will be followed by a seminar with presentations on the « Tantalum Raw Material Supply ».

On Tuesday, May 15th, a visit will be made to the mining operations of Greenbushes Tin N.L. with other tours and excursions in the area available to participants on the following days.

The meeting, seminar and tours will be open to members of the T.I.C. and guests of members only.

Western Australia

The site of the Eleventh General Assembly of the Tantalum Producers International Study Center will be in Perth, the capital of Western Australia. This state of the Australian Commonwealth fronts on the Indian Ocean and is almost 2,000 miles and three time zones removed from most other Australian cities, located on the eastern coast of the continent. The population of the entire state is only 1.2 million and 750,000 of these people live in the city of Perth. The tremendous mineral wealth of Western Australia, just beginning to be developed, has made Perth a regular boomtown. But even with the flavour and spirit of a frontier town, Perth is a beautiful, modern city resplendent with waterways, parks and other attractions for the visitor. Perth has more days of sunshine than any other capital city in Australia and has an international reputation for warm hospitality.

The vast mineral resources of Western Australia ensure that Perth will be the capital of the minerals world for many decades to come. Reported estimates of the mineral resources seem almost astronomical :

— 37 billion tons of high-grade iron ore.
— 400 million tons of coal.
— 66 billion tons of uranium ore.
— 3 billion tons of bauxite.
— 110 million tons of mineral sands.
— 6 million tons of nickel ore.
— 2 million tons of copper ore.
— 250,000 kilogrammes of gold.

In addition, the offshore area of Western Australia is considered

to be one of the world's major undeveloped gas and oil reserves. The exports of minerals in 1977 were valued at $ 1.9 billion which included $ 1 billion of iron ore.
The mine of Greenbushes Tin N.L. is located in Greenbushes Town on the Southwest Highway 254 kilometers south of Perth. The Highway wanders through a wonderfully green and fertile land where dairying, fruit-growing and market gardening are the principal activities. The mineral field in which the mine is located is situated in a hardwood forest. Topographically, the field is a laterite capped plateau with numerous old and rejuvenated streams flowing from it into the Blackwood River Valley. The highest point in the field is 329 meters above sea-level, and the lowest point is approximately 122 meters.
Climatic conditions at the location are temperate with a December high of 28 °C and a July low of about 4 °C. The average annual rainfall is 100 centimeters, mostly during the winter months, although some rain can be expected throughout the year.

The Greenbushes Mineral Field

The mining history of the Greenbushes area began in 1884 when a local kangaroo shooter, on the advice of a geologist, began prospecting for alluvial cassiterite. His efforts were rewarded in 1888. From that time onward, individual miners and small companies have worked the primary pegmatites and secondary alluvial deposits. Mining activities have varied over the years. The present operator, Greenbushes Tin N.L., is the largest in the history of the field. Greenbushes Tin started operations in 1963 and has been in continuous operation ever since.
The main pegmatite dyke in the field outcrops for about 2.4 kilometers, running almost parallel to the South West Highway. It dips to the west at roughly 65 degrees from the horizontal. It varies in width from 60 to 250 meters and both the pegmatite and « greenstone » country rocks are weathered down to at least 48 meters. The zones of cassiterite and tantalite mineralization mainly occur on the western and eastern margins where the pegmatite contacts the « greenstone ».
The main pegmatite body is elevated and most of the gritty material has washed down from the weathered pegmatite and has accumulated in surrounding areas as alluvial deposits. These deposits are loosely cemented and are never more than 9 meters thick. Most of the heavy minerals are found in the bottom 1.5 meters of sediment.
In addition to the production of cassiterite, tantalite and stibnio-tantalite, the field has been shown to be a source of quality kaolin products. Gallium is known to be present in small amounts in the plentiful tourmaline minerals. Zircon and ilmenite are as plentiful as the cassiterite and tantalite.

Publication of the Proceedings of the First International Symposium on Tantalum

The papers presented at the First International Symposium on Tantalum have been published in book form for distribution to members and others. Mailing will take place during March. The book contains almost two hundred pages and includes the pictures, charts and statistical data used in each presentation. The discussion which followed each presentation has also been reported.

An additional article, « The Miners' Response to the Forecasted Shortage of Tantalum » has also been included in the book. It was prepared particularly for inclusion by Mr. A.C.A. Howe of A.C.A. Howe International, Ltd. of Toronto, Canada, and Mr. Hans W. Schreiber of Behre Dolbear & Company of New York, both internationally known consultants in the mining field. This paper presents the viewpoint of the miner, the possible reasons for the presently muted response, and the likely future response which may be expected by the fabrication industry. The short-term effects of the price increase of tantalite on the supply are evaluated. The long-term prospects for increasing the supply from new deposits of tantalite are defined, and the means by which the effort required to locate new sources could be supported are suggested.

Copies of the book can be purchased by non-T.I.C. members for US $ 25 each. Orders should be addressed to the Tantalum Producers International Study Center in care of Mrs. Judith Wickens, Secretary, at 1, rue aux Laines, 1000 Brussels, Belgium. The order should be accompanied by a draft covering payment for the books ordered.

Hafnium-Nobium Carbide, a substitute for Tantalum Carbide

During 1978, at the First International Symposium on Tantalum, Professor Dr. R. Kieffer of the Technical University of Vienna suggested the use of a double carbide, hafnium-niobium carbide, as a satisfactory replacement for tantalum carbide in many cutting tool applications. Although Professor Kieffer did not indicate that this double carbide was available commercially, it has been introduced to the marketplace since that time by Teledyne Wah Chang Albany. As the free world's major producer of hafnium (a co-product of zirconium) and one of the major producers of niobium products, it seems natural that Teledyne Wah Chang would be the producer of the new product.
Development work began in 1977. Various mixtures of hafnium and niobium were blended and carburized. These were incorporated in standard grade C-5 and C-7 cemented carbide cutting tools which were then tested and evaluated independently by the Oregon Institute of Technology. The results showed that not only is hafnium-niobium carbide a viable substitute for the tantalum carbide in these grades of cutting tools, it also provides improved characteristics in such factors as edge wear, crater wear, and thermal deformation.
Teledyne Wah Chang is the sole licensee of the basic patent authorized to market the double carbide. They have had this licence for five years. A marketing campaign has been initiated which has resulted in immediate response from the producers and users of tantalum carbide and from the consumers of cemented carbide tools. There have been 60 to 70 requests for additional information including those received from such major companies as Caterpillar, Ford Motor, Teledyne Firth Stirling, Kennametal, and Hermann C. Starck. The effort to introduce the new product is being broadened outside the United States to Europe and Japan.
The interest in the use of hafnium-niobium carbide is economic and has only become possible as a result of the meteoric rise in the price of tantalum carbide. At present, quoted prices for tantalum carbide vary from US $ 56 to $ 59 per pound. The hafnium-niobium carbide is currently quoted at US $ 30.25 per pound. Since, on the basis of a one-to-one substitution of the double carbide for tantalum carbide results in only about 75 % of the weight required, the substitution would result in an effective cost (of that component of the cemented carbide material content) of 40 % of the cost of using tantalum carbide. Thus, there is considerable economic motivation for the tool producers to apply the hafnium-niobium carbide widely, particularly in view of the fact that tantalum carbide prices are expected to continue to increase and the hafnium-niobium carbide prices are expected to remain stable for an extended period of time.
The hafnium-niobium carbide will not ever become a total substitute for tantalum carbide even if it should become universally accepted. Hafnium occurs in nature only in combination with zirconium ranging up to about 2 % of the zirconium in the mineral sands. Generally, for applications such as refractories, the hafnium is not separated from the zirconium. It is recovered only in the processing to produce zirconium metal as a matter of necessity in order that the zirconium can be used for nuclear purposes. With the slow-down in the installation of new nuclear power plants, the principal application of metallic zirconium, the production of hafnium is limited. Considering other uses for hafnium, production of the double carbide will probably be limited to 175,000 to 250,000 pounds per year. This quantity could replace 225,000 to 325,000 pounds per year of tantalum carbide if the available hafnium-niobium carbide would be totally applied. Therefore, at most, the substitution would be limited to about 25 % to 35 % of the forecast tantalum carbide usage for the 1980 to 1985 period. Such total substitution would reduce the demand for Ta_2O_5 in source materials (tantalite, columbite, and tin slags) by 300,000 to 400,000 pounds, about 10 % of the free world demand.
Since Teledyne Wah Chang is actively pursuing other applications for hafnium, it is likely that the availability of the double carbide will be further reduced. An example is the successful development of the use of hafnium nitride as a coating for cemented carbide tool bits, replacing titanium carbide which is used extensively for coating. The Wah Chang Research Department has been working for almost six years on this application. It has been demonstrated that hafnium nitride coating increases tool life over tools coated with titanium by two to three times. The new tools also can better withstand the high temperatures generated during cutting. Wah Chang's sister company, Teledyne

Firth Stirling, is a major producer of coated cutting tools and has developed the market for the hafnium nitride coated tools. Late last year, the Research Department at Wah Chang reached an end of the laboratory phase of the project at a monthly production rate of 35,000 tool bits. The production phase at Firth Stirling is now under way.

Tantalum Carbide Free Steel Cutting Grade Tool Alloys

The following article was written by Dr. P. H. Booker, Carbide Development Metallurgist, and R.E. Curtis, Manager of Metallurgical R & D, of Teledyne Wah Chang Albany, and it was published in « Cutting Tool Engineering » in October 1978.

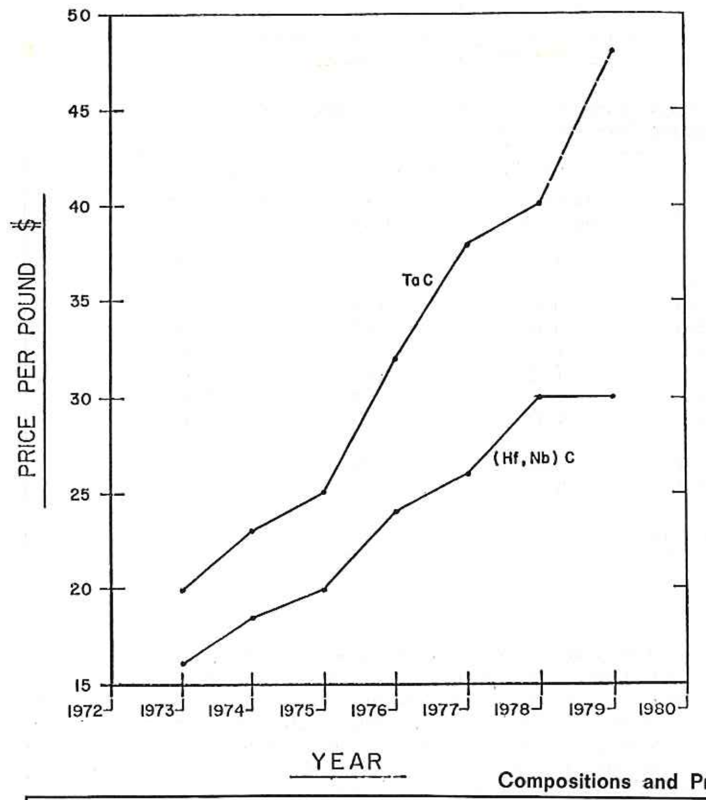
Tantalum carbide poses a special problem to the cemented carbide industry now, in that the time of cheap and sufficiently available virgin tantalum is ending (1). In the past five years alone, tantalum carbide costs have gone up 100 %. Despite the fact that the use of virgin tantalum carbide is being reduced through recycle hard metal scrap and tantalum carbide free tool alloys, there is a need for a more economic and available substitute to assure continued high performance cutting tool availability, particularly at a reduced cost.
To fill this need, cutting tools using substituted low-cost and available hafnium-niobium carbide were developed in this study. The tools developed are for machining steels in the C-5 (roughing) to C-7 (light finishing) grades.

Cost Savings

Significant cost savings are achieved in these cutting tool alloys because of the relatively low cost of (Hf, Nb) C. The following chart shows the current cost per pound of (60 wt % Hf - 40 wt % Nb) C is 25 % lower than TaC. Even greater savings are realized in actual cutting tool costs because on a weight percentage basis less (Hf, Nb) C is required when making a direct substitute for TaC.

Cutting Tool Alloying

Presently, commercial carbide tool alloys used for the machining of steel in the C-5 to C-7 class are formulated from titanium-tantalum-tungsten carbide/cobalt compositions. The hardness and wear resistant carbide phases in a typical steel roughing grade consist of comparable volume percentages of
— A cubic carbide solid solution containing practically all of the titanium and tantalum, as well as some tungsten, and
— Unalloyed tungsten carbide.
In terms of cutting performance, titanium carbide provides wear and crater resistance while tantalum carbide improves thermal deformation resistance and also adds to the crater wear properties without detrimentally affecting alloy toughness. The high thermal conductivity of tungsten carbide (relative to the cubic carbide solid solution) combined with its good binder wetting properties imparts adequate toughness and thermal shock resistance to these composites.
Past investigations (2,3) indicate that niobium carbide and hafnium carbide are effective substitutes for tantalum carbide as cubic carbide additions. They are known to improve wear performance of steel cutting grade tool alloys (4,5), but data on strength and toughness properties are conflicting.



(Hf, Nb) C Modified Tool Alloys and Their Evaluation

Based on the promising results of past investigations, a study was initiated to develop tool alloys containing hafnium-niobium carbide solid solutions (60-65 % HfC, balance NbC) in replacement of tantalum carbide. Alloy grades from the C-5 and C-7 class were fabricated in order to evaluate their wear (edge and crater) and thermal deformation resistance during the cutting of steel, as well as the alloys' physical properties.
Compositions of selected alloys evaluated follow along with those for the two commercial alloys C-5 and C-7 grades which were purchased. Transverse rupture strengths for the commercial grades were measured on test bars cut from the as-supplied tool inserts (see table below).
Aside from routine fabrication variables, the grain size distribution of the carbides, as well as the milling and sintering conditions, strongly influence microstructure and phase constituents and, as a result, the properties of the sintered tool alloys. In particular, by not over-sintering the hafnium-niobium carbide containing tools, grain growth of the carbide constituents was not a problem, and the grain size distribution in the sintered alloys was controlled by the formulated distribution in the as-milled state.

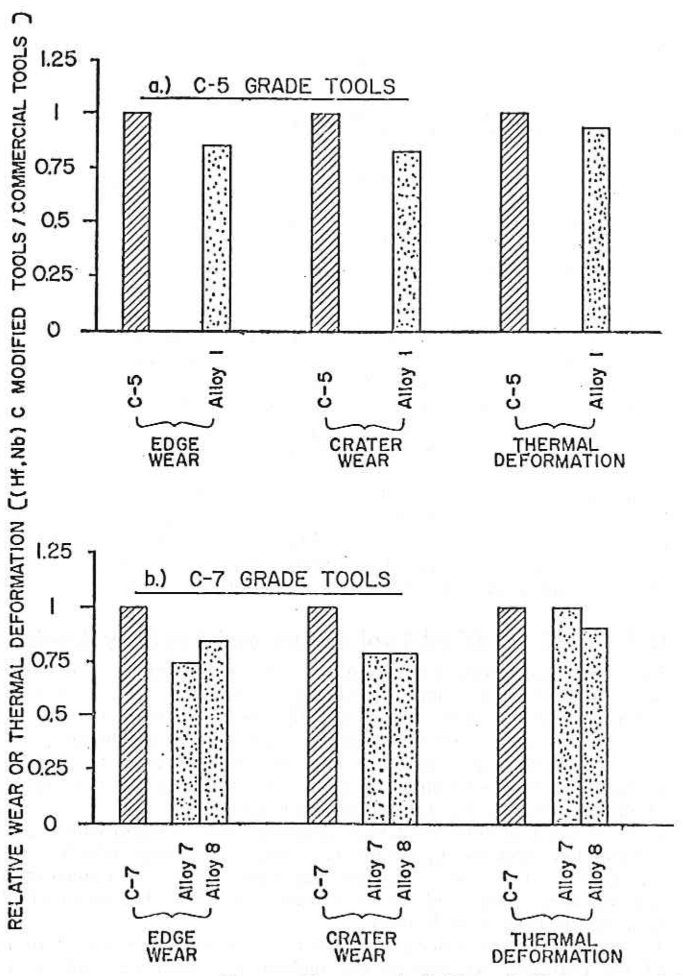
Performance Comparison

For equivalently alloyed C-5 and C-7 grades, edge and crater wear resistance of the (Hf, Nb) C modified alloys were found to be superior to commercial alloys containing TaC (see chart p. 4). Thermal deformation resistance was equivalent or slightly better. In terms of strength and hardness, the (Hf, Nb) C modified alloys have slightly higher levels of both properties when compared to the TaC containing alloys (compare C-5 versus Alloy 1 and C-7 versus Alloy 7). Comparison of equivalently alloyed grades gives a direct indication of the effect of substituting (Hf, Nb) C for TaC since gross amounts of the carbide components are equal (on a mole fraction basis) in the commercial and modified alloys. The volume percent binder was also maintained approximately equivalent.
For (Hf, Nb) C modified alloys with higher than equivalent WC contents (Alloys 2 and 3 for the C-5 class and Alloys 8 and 9 for the C-7 class), edge and crater wear resistance and thermal deformation resistance are equal to the commercial TaC containing alloys. Strength properties of these higher WC content alloys are improved (see table below).

Compositions and Properties of Tool Alloys

Alloy No.	Composition, wt. % TiC	TaC	(Hf, Nb) C *	WC	Co	Transverse Rupture Strength, ksi	Hardness RA + 0.1	Density gm/cc
C-5 **	8.0	10.8	—	72.7	8.5	255.0 ± 10.0	91.3	12.60
1	8.2	—	8.5	74.2	9.1	263.6 ± 19.0	91.5	12.06
2	8.5	—	4.2	78.3	9.0	284.4 ± 13.1	91.0	12.27
3	6.6	—	8.2	76.3	8.9	302.5 ± 12.1	90.9	12.44
4	6.5	—	4.0	80.8	8.7	317.3 ± 14.6	90.7	12.69
5	4.7	—	7.9	78.5	8.9	320.6 ± 17.7	90.8	12.85
6	4.7	—	3.9	82.7	8.7	327.8 ± 12.6	90.3	13.11
C-7 ***	12.4	12.2	—	70.9	4.5	215.0 ± 14.1	92.5	12.04
7	12.7	—	9.6	72.7	5.0	231.1 ± 8.4	92.8	11.45
8	11.3	—	9.3	74.5	4.9	234.1 ± 10.9	92.6	11.73
9	9.0	—	9.0	77.3	4.7	249.8 ± 10.9	92.5	12.21
10	8.9	—	4.4	82.1	4.6	244.2 ± 10.4	92.4	12.47

* 60 % HfC - 40 % NbC   ** Commercial C-5 Grade   *** Commercial C-7 Grade



Replacement of TaC with (Hf, Nb) C also resulted in higher toughness cutting tool alloys. As demonstrated by the modified C-5 type alloys 4 to 6 and C-7 alloy 10, toughness qualities and thermal shock resistance are improved by increasing the binder content and/or grain size and the amount of the WC-phase at some sacrifice to thermal deformation and wear resistance. These alloys are designated for interrupted machining or heavy to light milling applications.

Conclusion

Superior edge and crater wear resistance, and at least equal thermal deformation resistance, have been achieved by replacing TaC with (Hf, Nb) C in equivalently alloyed C-5 and C-7 class cutting tools. Strength, hardness, and grain growth stability of these modified alloys equal those for commercial TaC containing alloys.

(Hf, Nb) C modified alloys having the same wear resistance as commercial grades can contain higher WC contents (at the same volume percent binder) resulting in improved strength. Other (Hf, Nb) C modified alloys will exhibit improved toughness and thermal shock resistance at some sacrifice to thermal deformation and wear resistance.

These improvements are all achieved with significantly lower cost raw materials. Based on first half 1978 prices, the savings for the modified (Hf, Nb) C alloys will be approximately 28 %. These cost savings are expected to increase in the future because current TaC prices are again rising, while (Hf, Nb) C is remaining stable and will remain so for the coming year.

References

(1) Albert Mari, « New Tantalum Sources Called Vital », American Metal Market, June 21, 1978.

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(3) R. Kieffer, G. Trabesinger, and N. Reiter, Planseeberichte fur Pulvermetallurgie, 17, 1969.

(4) United States Patent No. 3,463,621 (1969), « Alloys of Sintered Carbides », R. Kieffer.

(5) United States Patent No. 3,994,692 (1978), « Sintered Carbonitride Tool Materials », E. Rudy.

Compositions and Cutting Performance of (Hf, Nb) C Modified Tool Alloys in Comparison To Commercial Tools Containing Tantalum Carbide

Alloy No.	Composition, wt. %					(Hf, Nb) C Modified/Commercial Tool Ratios **		
	TiC	TaC	(Hf, Nb) C *	WC	Co	Relative Edge Wear	Relative Crater Wear	Relative Thermal Deformation
C-5 ***	8.0	10.8	—	72.7	8.5	1.00	1.00	1.00
1	8.2	—	8.5	74.2	9.1	0.86	0.83	0.95
2	8.5	—	4.2	78.3	9.0	0.93	0.89	1.05
3	6.6	—	8.2	76.3	8.9	0.97	1.01	1.03
4	6.5	—	4.0	80.8	8.7	1.13	1.04	1.10
5	4.7	—	7.9	78.5	8.9	1.02	1.05	1.25
6	4.7	—	3.9	82.7	8.7	1.17	1.20	1.19
C-7 ***	12.4	12.2	—	70.9	4.5	1.00	1.00	1.00
7	12.7	—	9.6	72.7	5.0	0.75	0.79	1.00
8	11.3	—	9.3	74.5	4.9	0.85	0.79	0.91
9	9.0	—	9.0	77.3	4.7	0.98	1.13	0.91
10	8.9	—	4.4	82.1	4.6	1.18	1.29	1.20

* 60 % HfC - 40 % NbC ** Test Condition : 4340 Steel, R *** Commercial Grade

Tanco Ownership Changed

The Manitoba, Canada, government announced in early November 1978 that it had approved the transfer of the stock held in the Tantalum Mining Corp. of Canada, Ltd. (TANCO) by International Chemalloy Corp. to the Hudson Bay Mining & Smelting Co. of Toronto, an affiliate of the Anglo-American Corp. of South Africa. The stock, representing a 50.01 % interest in TANCO, was purchased from the receivers of Chemalloy, the company having entered bankruptcy in 1975, for $ 6.5 million (Canadian). Hudson Bay has sold 12.51 % interest to Kawecki Berylco Industries, Inc. thus reducing its net investment to $ 4.9 million. The net result is that both Hudson Bay and Kawecki Berylco own 37.5 % of TANCO and the remaining 25 % is held by the Manitoba Development Corporation, a provincial development agency owned by the Manitoba government.

The mine site of TANCO is located 110 miles by road from Winnipeg, Manitoba, in a northeasterly direction. The location was first discovered in the 1920's by gold prospectors who located a narrow dyke containing some tin ores. Further exploration led to the discovery of the large sill hidden beneath Bernic Lake. After some drilling and sinking a small shaft, the property was acquired in 1925 by the predecessor company of Chemalloy. Further exploration and shaft sinking occurred until 1962 when the mine was allowed to flood. In late 1966 and 1967 the mine was reopened and, after further exploration, TANCO was formed in November 1967. A concentrating plant was built and run-in during the summer of 1969 and the plant went into full production in September 1969. Since that time, TANCO has been the world's largest producer of tantalite, supplying almost 20 % of the free-world's supply of tantalum source materials.

The tantalum reserves are becoming exhausted and are expected to end within a few years. But there are large reserves of spodumene and lepidolite, lithium minerals, which have been reported to be in excess of 5.0 million tons, containing about 2.6 % lithium oxide. A pilot plant to produce ceramic-grade spodumene, used by the glass and ceramic industries, was built in 1973. Now, approval has been obtained to study the feasibility of building a $ 55 million (Canadian) lithium chemical plant at the site. Lithium is used in a variety of products including glass, ceramics, pharmaceuticals and lubricants. The major developing markets are in aluminium smelting and long-life batteries.

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