TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN JUNE 1976 SECOND QUARTER

Activities of the T. I. C. - Fifth General Assembly

The business of the Fifth General Assembly centered around the admission of new members, the T.I.C. Study - Phase II, and the clarification of by-laws for the benefit of new members.

MEMBERSHIP

Applications for membership in the T.I.C. had been received from nine companies, such applications submitted under the change in the by-laws broadening membership to include all producers of columbite-tantalite, processors of columbite-tantalite, companies which transform or treat products, and international companies engaged in trading columbite-tantalite raw material who assist financially or technically in the production of such material by miners who are not members of T.I.C.

All applications were unanimously approved by the membership. (See back page for the listing of the new members.) Two companies have also signified their interest in membership in the T.I.C., but have not yet submitted applications. Several other companies have advised that they are considering their interest. Two present member companies, Cobelmin-Zaire and Symetain, have combined to form a new company, Sominki, who will now be the member of T.I.C.

T.I.C. STUDY PHASE II

The Phase II study will assess the worldwide demand for tantalum over the next five years specifically in four areas :

1. The current end-use demand for tantalum products,
2. The planned consumption of tantalum containing products, 1976-1981,
3. The sensitivity of the forecasts to substitution, price, and time factors of substitution,
4. The implications of planned consumption for the tantalum industry.

The T.I.C. has solicited general industry support for the study, both from members of the T.I.C. and non-members.

At the time of the General Assembly, twenty-two companies, including two non-members, have provided or committed contributions for the study. Companies not yet committed were urged to reach a decision as quickly as possible.

The General Assembly authorized the President to engage the services of Emory Ayers Associates of New York to begin the " Study - Phase II " based on present commitments, the work to be expanded as additional contributions are received.

CLARIFICATION OF BY-LAWS

1. A question was raised concerning the requirement for the presence of legal counsel at meetings. Although the by-laws do not require such, the President invited any members who so desired to bring their own legal counsel to the meetings. If the T.I.C. membership as a whole decides that a permanent T.I.C. lawyer should be appointed, the by-laws will be so amended.

2. Since the by-laws require a two-thirds vote in favor of the admission of new members, concern was expressed that eligible candidates might be excluded in the future. The President stated that Belgian law, under which the T.I.C. is chartered, would prohibit such interpretation of the by-laws. A clarification and interpretation of the by-laws will be sought by the Executive Committee.

3. The Charter is not considered sufficiently clear on the determination of membership fees. By Assembly action, a flat fixed annual fee has been established applicable to all members. The by-laws permit the basis for fees to be changed from time to time by the membership.

4. The stated aims of the T.I.C. includes the phrase « to coordinate the whole market ». Concern was expressed that such could include price coordination. The President stated that there is no such intent and that the aims are to provide awareness of market conditions through the collection and distribution of statistics and studies authorized by the membership.

T.I.C. FIFTH GENERAL ASSEMBLY

On March 25, 1976 the Fifth General Assembly of the T.I.C. convened in Brussels. Eight members were in attendance. Others attending included eight new member applicants and three guests who are considering membership. Two presentations were made :

" Tantalum - The Exploration Challenge "
by Dr. Pierre Evrard, Professor of Liege University and Chairman of Natural Resources Consultants, S.A.

" A Geogologist's Overview on Tantalum "
by Mr. Hans Schreiber, President of Behre Dolbear & Co., Inc., geological consultants, New York.

The next General Assembly will be held in Brussels on Tuesday, October 12, 1976.

MISCELLANEOUS BUSINESS

The effort to find a Technical Advisor to the T.I.C. has so far been unsuccessful as no one has been identified as suitably qualified who resides in Brussels. The President requested members to provide suggestions and eliminated the absolute need of residence in Brussels.

Statistics for 1975 were circulated to members but such are not yet complete because some members have not submitted their data. No publication of the statistics will be made until they are complete.

A Geologist's Overview on Tantalum

Condensation of a paper presented to the Fifth General Assembly of the T.I.C. on March 25, 1976 by Mr. Hans W. Schreiber

The main purpose as a geologist is to indicate some of the inherent difficulties nature has imposed upon man as far as the occurrence of tantalum is concerned and man's finding of such occurrences. The difficulties are such that if tantalum is to have a hope of primary production—as a commodity in its own right and not merely as a by-product of tin—price fluctuations will need to be modified and the general price levels will have to be increased.

The minerals have some inherent, unattractive characteristics. Tantalite and microlite are the tantalum rich end of an isomorphus series: columbite to tantalite, and pyrochlor to microlite. In the columbite-tantalite series (Fe, Mn) $(Nb, Ta)_2O_6$, the iron and manganese may substitute completely for each other, similarly, niobium and tantalum. The pure niobium end member could contain 83 % Cb_2O_5 and the pure tantalum end member 86 % Ta_2O_5. But the pure members seldom exist so that both are generally present. Furthermore, the proportion of each may vary widely within a single small area or deposit. In the pyrochlor-microlite series $(Na, Ca, Ce)_2$ $(Nb, Ti, Ta)_2$ $(O, OH, F)_7$, the three elements within each bracket may freely substitute for any of the others. The pure niobium end member can contain up to 73 % Cb_2O_5 and the pure tantalum end member up to 82 % Ta_2O_5, but such is very seldom the case. The chemical situation translates into two considerations:

1. Niobium and tantalum usually occur together and usually niobium exceeds tantalum in a ratio of between 5 and 10 to 1. There is no tantalum without niobium.
2. Both the recovery and the value of concentrates can be rendered highly variable unless grade/chemical control and a mining plan are worked out in advance of operations.

Tantalum is chemically very inactive. It combines with relatively few other elements and is soluble only with difficulty. As a result, the metal does not move far from its original location, i.e., tantalum has limited geographical dispersion.

Tantalum is not found in its native state but combines with oxygen or hydroxide to form minerals of lower specific gravity than cassiterite and wolframite. As a result, there is an ubiquitous tendency for tantalum bearing minerals to undergo substantially less natural concentration in alluvials than is the case for the tin and tungsten bearing materials. Also, tantalum does not combine with sulfur, which means that flotation of tantalum minerals is more difficult and more expensive.

There are three geological deposit types —carbonatites, pegmatites, and contact metasomatic deposits—which can be thought of as the end products of a melt. Any elements which did not crystallize out as the melt cooled, or as pressures changed, will likely be found in these three deposit types. Carbonatites offer the best prospect for contained tantalum tonnage, but tantalum is unlikely to be present in economic concentration. Of almost 200 known carbonatites, half contain niobium and tantalum and only 20 % contain metals in possible future economic concentration, Ta_2O_5 is generally less than 0.01 %. Granite pegmatites are the best prospect for grade and favorable Cb : Ta ratio, but less than 1 % of the thousands of known pegmatites are economical for any material. Pegmatites occur both zoned and unzoned. Metallic constituents in unzoned pegmatites occur in an entirely heterogeneous fashion, making grade determination very difficult. Zoned pegmatites are easier to evaluate, but are not as abundant. Ta_2O_5 grade rarely exceeds 0.25 %. Alluvial and eluvial deposits are the best prospects for low production costs. The ideal weather conditions to break up the host rock occur in tropic zones; ideal transport conditions occur in temperate zones. Since the host exposure and transport conditions must all be right, these deposits are rare. Those that do exist are generally small. Because of the relatively low specific gravity of tantalum minerals, grade is seldom increased substantially over that of the source deposit. In summary, carbonatites, syenites, and pegmatites are in themselves unusual, comprising only an infinitesimally small part of the rock compared to common granites, limestones, etc.

The United States is the most politically attractive country for mineral exploration, but it is not blessed with an abundance of the required geological settings. Canada requires further political improvement before substantial exploration can be justified. Geologically, the potential is good, particularly for pegmatites. However, exploration costs can be expected to be high. The geological potential of Brazil—in terms of pegmatites and carbonatites—is probably the best in the world. The country is undergoing a transition with respect to foreign investment policies, and, at present, only modest programs are advisable. Western Australia has a large number of Ta and Nb occurrences, many of which have been inadequately investigated. Political attractions of the country were damaged by the nationalistic policies of the Labor Party. These are now undergoing modification. It is unlikely to be as attractive, however, as it once was.

As long as deposits appear to have a general tenor of 0.1 % Ta_2O_5 at a gross value of $30 per ton, tantalum will likely continue to be a by-product. Underground mining and milling costs are today at least $15 per ton and an additional $15 is just not enough to cover overheads, pre-deposit exploration, taxes, interest, and return on equity. Although market, i.e., « demand », is probably the most important price determiner, part of the price for any commodity is determined by its production costs. When production is not a function of a particularly difficult and expensive technological process, the production cost is a function of the concentration ratio. Tantalum generally has a concentration ratio of 300 to 500, compared to 25/40 for copper, 15/25 for zinc, 20/30 for lead, and 50/700 for tin.

A careful study comparing grade/concentration ratios for commodities using approximately the same concentration process and relative abundance/frequency of known deposits of commodities using similar concentration processes might well show that the rarity of tantalum deposits is not sufficiently reflected in the current price and that the price might justifiably be twice as great.

A parallel might be drawn from the recent increase in uranium prices and possible future increases in tantalum prices. The uranium price was simply too low to stimulate or encourage exploration, given both the concentration factor and the occurrence frequency of the deposit at the average concentration factor. Once the low relative abundance of tantalum is realized and accepted by fabricators/product users, the price of tantalum will likely increase. When it does, it will remain the obligation of both producers and fabricators of tantalum to keep the increase orderly, and not allow any price fall-backs to drop to levels which discourage and stifle exploration.

Tantalum Mining Corporation of Canada Limited (Bernic Lake)

TANTALITE OPERATIONS

Mining

The underground mine can be entered either by the 550 foot vertical shaft (used for hoisting ore) or via the 20 % decline (used for vehicle access). The shaft connects to both levels of the mine; and the incline to the first (282 foot) level and the mining area.

The tantalite orebody lies mostly beneath the lake at minimum depth of 180 feet from the lake bottom. The ore is mined by a room and pillar method, with 50 foot wide rooms, and 50 foot square support pillars. Between the pillars the roof of the mined out area is arched (like a cathedral). Two zones are being mined at present.

The production crew on each of the two shifts comprises of one miner operating the two-machine diesel-driven drilling jumbo, one miner on the diesel-powered 5 yard loader, and two others blasting, maintaining roads, and checking the roof with the 60 foot reach « giraffe ». Additional men are used for development ,preparing the areas for « stoping » and maintenance.

After the ore is drilled and blasted, it is dropped through orepasses to the second level at 436 feet below ground. Here a miner using a 4-ton diesel locomotive and 4-ton self-tipping cars hauls the ore to the shaft. In the shaft the ore is hoisted in 2-1/2 ton skips, by the 200 hp hoist, at a rate of 2-1/2 tons per minute.

Milling

The skips dump the ore into coarse ore bins, located at the shaft, from which the ore is carried to the crushing plant by conveyor. The crushing plant will handle about 140 tons per hour, and only needs to run on one shift per day.

First, the ore goes through the jaw crusher, which is set to crush to 4 inches, and then passes to the 3-deck screen. Material passing right through the three screens (1/2 inch or less in diameter) is conveyed to the fine ore bins, while oversize goes to either of the two cone crushers for further reduction.

The fine ore is stored in three 500 ton fine ore bins before passing to the 24 hour per day concentrating section. Firstly, the ore goes to an 8' x 12' rubber lined ball mill, where a 30 ton load of tumbling steel balls grinds the ore to about 85 % minus 65 mesh, returning the screen oversize material to the mill. The ground ore passes to 27 rougher concentrating tables. Here, by a shaking and settling action, the first separation of tantalite is made, being upgraded from about 0.15 % to about 4 % Ta_2O_5. This rougher concentrates slurry is thickened and stored for further cleaning. The « middling » material is returned to a 6' x 4 1/2' ball mill for further grinding and is then returned to the circuit. The tailing is sent to a screening area where the fines (slimes) are separated from the sands for subsequent processing.

The cleaner circuit consists of a small ball mill, a screen, three cleaner concentrating tables and a magnetic separator. Here the rough concentrate is upgraded to about 50 % Ta_2O_5 before drying and packing in steel drums.

The sands from the screening plant are pumped to a storage area for future use as a feldspathic sand.

The fines are sent to six Bartles-Mozley concentrators, and then to ten Holman « slime-deck » tables, the concentrate from them is fed to one Deister slime deck table to produce a further final concentrate which is added to that described above. The waste products are combined and pumped to a tailing storage area. The deposited tailing is levelled each year and seeded to produce a self-sustaining crop of grasses.

The mill is operated on a 24-hour day, 5-day week basis, by two men only one each shift, plus one crushing plant operator. On the day shift there is also a maintenance crew, laborator crew, and one man sampling.

The tantalum concentrator recovery of the Ta_2O_5 from the ore varied from 60 % to 65 % during the first years of the operation and was increased to 65 % to 70 % during 1974 by addition of a regrinding and screening circuit. In late 1975 another section was added to the concentrator in order to retreat the slimes. This new section is currently in the tune-in stage with recoveries about 70-75 % of the contained Ta_2O_5, and is expected to reach 75 % to 80 % in early 1976.

PRODUCTION OF TANTALITE CONCENTRATES

The company commenced full scale production in September, 1969, although some tantalite was produced during the run-in period prior to that.

In 1973 tantalum concentrate production was stopped owing to the world market conditions and instead pilot plant operation to produce ceramic quality low-iron spodumene concentrates was carried out.

Production of contained Ta_2O_5 by years is as follows :

Year	Lbs. Contained Ta_2O_5
1969	164,291.01
1970	424,092.50
1971	355,879.55
1972	326,083.60
1973	55,013.78
1974	268,469.02
1975	399,053.81
Total	1,992,883.27

The average content of concentrate produced in 1975 was 51.5 % Ta_2O_5, 13.4 % SnO_2, 1.3 % TiO_2, and 3.9 % Cb_2O_5.

ASSOCIATED MINERALS

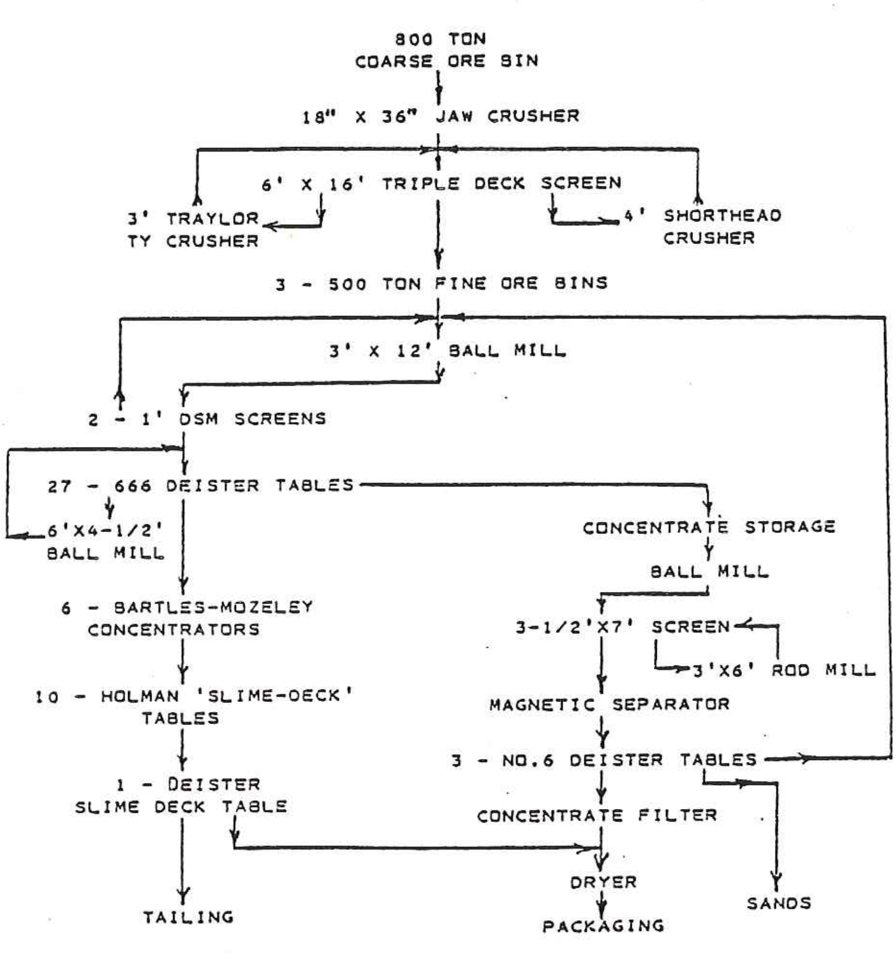
There are other minerals of economic value contained in the pegmatite as follows :

Spodumene - 5 million tons containing 2.6 % Li_2O.
Lepidolite - 107,700 tons averaging 2.4 % Li_2O.
Pollucite - 300,000 tons averaging 23 % Cs_2O.
Beryl - 1 million short tons averaging 0.22 % BeO.

A pilot plant research addition to the mill was built in 1973 and operated during that year to produce ceramic grade spodumene for the glass/ceramic industry. The plant proved out the process for producing an exceptionally high quality low-iron ceramic grade product.

Tanco proposes to expand the present concentrating facility to produce both ceramic grade spodumene and a chemical grade spodumene concentrate. A chemical

SCHEMATIC FLOWSHEET



plant to produce lithium carbonate is also planned, which will process the spodumene concentrate produced by the mine. Shipments of pollucite ore have been made each year in quantities up to 500 metric tons.

GALLIUM AND RUBIDIUM

Although there are no gallium or rubidium minerals present, the elements occur as replacements in other minerals. The rubidium, like lithium, replaces alkali metals in the micas and feldspars. Concentrations in the lepidolite zone have made possible mining and shipping of ore containing about 4 % Rb_2O.

Gallium occurs as a replacement for Al_2O_3 in the feldspars and micas; in the pure micas the content is about 0.05 % Ga throughout the pegmatite, and the tantalum ores being mined average about 0.02 % Ga.

Tantalum
The Exploration Challenge

Condensation of a paper presented to the Fifth General Assembly of the T.I.C. on March 25, 1976 by Dr. Pierre Evrard

Tantaliferous minerals such as tantalite, tantalo-niobate, are rare, heavy, wear and weather resistant minerals. Thoreaulite is a tin-tantalite, but is a curiosity. Others, such as the pyrochlor-microlite series, are a potential source. Tantalum is also recovered from tin slags. Referring to the chemical composition of the earth crust, it is estimated that, for a thickness of 16 km., tantalum exists at 2.1 p.p.m. and niobium at 24.0 p.p.m. Therefore, the understanding required to locate economically mineable bodies of tantalum depends upon the answers to two questions :

1. What are the geological processes by which metals so rarely distributed in the crust are collected by internal fluids and transported during the crystallization of the magma or are percolated through rocks ?
2. When and why are they concentrated as minerals and in which geological environments ?

To answer these questions, an understanding is required of the principle of zonal distribution. Around an intrusive body, there is a radial distribution of chemical elements, a radial distribution of the minerals in which they are combined, and a radial distribution of gangue. It is also necessary to recognize that some kinds of rocks are preferred hosts to certain minerals. As an example, around an intrusive acid granite, there are concentric zones (always in the same order) of different types of pegmatites progressively passing to quartz veins at greater distances. The granites, now occuring at or near the surface, were intruded at different depths and outcrop as the result of tectonic movements and erosion. The spatial distribution away from the intrusion depends on the depth of the intrusion which determined the pressure, temperature, and rate of cooling which, in turn, controlled the crystallization of the molten magma and the escape of fluids. The degree of subsequent erosion has determined the mineral levels in the intruded massive and in the satellite bodies in the surrounding and overlaying rocks. The pegmatites are in the granite or not far away at the points of contact with the intruded rocks. Quartz veins may be either near or far away from the granite. Carbonate dikes or veins, fluorine, and baryte are found far away and often without an apparent connection with the granitic rocks.

Tantalites and tantalo-niobates are exclusively connected with granitic pegmatites, but the pyrochlor-microlite series are connected with the carbonate and alkaline-syenite rocks. Tin is associated with quartz veins, farther from the granite, and wolframite is in the quartz veins still farther away. Thus, when mining a pegmatic deposit for cassiterite, the content of tantalo-niobate might be so low that it is recovered only in the slag from the tin smelting.

In the continuous tantalo-niobate series, the tantalum content is higher with higher temperatures of crystallization, i.e., when it is closer to the parent rock. However, there are never great accumulations of these minerals since they occur as minute crystals spread all over the big pegmatite massive, particularly in the zones where these bodies passed through transformations called albitization. Consequently, it can not be expected to find an ore body rich in tantalite or tantalo-niobate concentrations as is found with lead, copper, or zinc. To find more tantalite will require thorough investigation of each tin district with a geological environment favorable to the presence of pegmatites.

Other intrusive rocks like alkaline-syenite, a granite without quartz but sodium rich with a high content of calcium, have engendered carbonatite rocks with associated ring structures. Here, the pyrochlor-microlite series are usual. Niobium largely dominates but these areas offer a potential source of tantalum that has not been fully explored.

Tantalo-niobates are never mined alone but are recovered as by-products of other metallic or non-metallic products found in pegmatites such as cassiterite, rare earth minerals, beryl, lithium minerals (spodumene and amblygonite), etc. The simultaneous recovery of all of these minerals, in many cases, is the only way to make a mining venture profitable.

Detailed studies of pegmatites, their textures, tectonics, and mineralizations offer the key to be used to find tantalum minerals. To increase production, it will be necessary to look for new reserves in new pegmatitic fields in remote parts of the world where the geology has not been explored in every detail. It can be expected that such will be in large unexplored countries such as Brazil and Bolivia.

T.I.C. MEMBERSHIP

During the Fifth General Assembly on 25 March 1976, the following companies were elected members of the T.I.C.

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