

T.I.C. Activities

The Tenth General Assembly of the T.I.C. was held on Friday 13th October 1978 in Brussels in the magnificent salons of the palace which once was the home of the Count of Flanders, father of King Albert of Belgium, and has now, for the last fifty years, been part of the headquarters of the Banque Bruxelles Lambert. The principal business of the meeting was the election of a new Executive Committee for 1978-1979 following the resignation of Mr. Reinhard Deil and the plan to expand the Committee from three to four members.

The new Executive Committee will be :

Mr. Joseph C. Abeles, President;
Mr. Herman Becker-Fluegel;
Mr. Paul Leynen;
Mr. Brian Reynolds.

The members expressed their appreciation to Mr. Deil for the very effective manner in which he contributed to the success of the First International Symposium on Tantalum and fulfilled his Presidency. Mr. Deil's resignation was occasioned by his withdrawal from association with the tantalum community due to a change in personal circumstances.

The new President, Mr. Joseph C. Abeles, is well known to all of the tantalum community as he is one of the pioneers responsible for the growth of tantalum processing during the past twenty-five years. His personal efforts have resulted in many of the current applications of tantalum and he has been a leader in the development of processing methods which have brought tantalum from the laboratory to the position of being a general commercial material.

Mr. Brian Reynolds, the other new Committee member, has recently represented the Thailand Smelting and Refining Co. at the T.I.C. He has also been long known in the tantalum community, however, as Managing Director of Kawecki-Billiton in England, and is now Manager Tin and Special Metals of Billiton in the Netherlands.

The newly elected member of the T.I.C. is Bhuket Union Thai Minerals, a mineral processing company in Thailand.

A discussion of statistic collection and compilation was held during the Assembly to determine the extent to which this function of the T.I.C. should be expanded and the means by which such should be accomplished. A presentation was made by the staff of the Liaison Committee for Non-Ferrous Metal Industries of the European Community on the general procedures and conditions under which they collect and publish statistical information covering metal production and products. The subsequent discussion of the staff and the members of T.I.C. led to conclusions which will be of great help to the T.I.C. in expanding this activity.

PROCEEDINGS OF THE FIRST INTERNATIONAL SYMPOSIUM ON TANTALUM

The transactions of the First International Symposium on Tantalum, held during May 1978 in Rothenburg ob der Tauber, West Germany,

T.I.C. TENTH GENERAL ASSEMBLY

On 13th October 1978, the Tenth General Assembly of the T.I.C. convened at the Banque Bruxelles Lambert in Brussels. Thirty-one participants represented twenty-five of the current thirty-two members.

The membership elected the Executive Committee for the coming year, increasing the number of members from three to four. Mr. Joseph C. Abeles, Chairman of Kawecki Berylco Industries, Inc. was elected President of the T.I.C. for the year 1978-1979.

One new member was elected to membership, increasing the roster to thirty-three.

The next meeting of the T.I.C. will be held in Perth, Western Australia from May 13th to May 17th 1979. The Eleventh General Assembly will convene on May 14th to be followed on May 15th and 16th by a visit to the mining operations of Greenbushes Tin NL, 150 miles south of Perth. The agenda will include a seminar on the current and future raw material supply.

are being prepared for publication as a hardcover printed book. This document will be available for distribution in March 1979. The book of proceedings will be available to those interested in purchasing a copy at a price of \$25.00 US per copy. Orders should be sent to Mrs. J. A. Wickens, Secretary,

Tantalum Producers International Study Center,

1 rue aux Laines, 1000 Brussels, Belgium.

Tantalum and Columbium Resources in Zaire

The tin mines in Zaire have been a major source of tantalum and columbium minerals for over fifty years. The principal historical source has been the major pegmatite lode at Manono in the northern Shaba province, located in eastern Zaire about midway between the northern and southern borders. In addition, there are scattered tin ore deposits in the northeastern part of the country in the Kivu-Maniema area. These have been mined in more recent years and have become an increasing source of columbo-tantalite concentrates.

The Manono site has long been operated by the Belgian company Compagnie Géologique et Minière des Ingénieurs et Industriels Belge (GEOMINES). In 1967, at the request of the Congolese Government, a new firm was formed, CONGO-ETAIN, owned 50 % by the Congolese Government and 50 % by GEOMINES. Under the terms of the reorganization, GEOMINES provides technical management and consultancy, personnel recruitment and marketing services. When the name of the country was changed in 1971, CONGO-ETAIN was also renamed ZAIRETAIN.

The mines in the Kivu area have been operated by a number of companies, principally PHIBRAKI (a joint venture of Philipps Brothers and SOBAKI, now of the Belgian Empain group) and COBELMIN (a subsidiary of Compagnie Belge d'Entreprises Minières). In 1974, a new company, the Société des Mines du Kivu (SOMINKI), was formed to merge these companies with other small tin miners in the expectation that the combination would be able to increase production more efficiently and economically than the individual companies.

All of the columbo-tantalite produced in Zaire is a co-product of tin mining. The columbo-tantalite is separated from tin concentrates, which are either smelted at Manono (ZAIRETAIN) or exported (SOMINKI). Since the final tin concentrates still contain significant tantalum and columbium, the tin slag produced at the Manono smelter is also a good source of these metals. The total production of tantalum source materials in Zaire has been as follows (1,000 lb. units of Ta₂O₅):

Year	Columbo-tantalite Concentrates	Tin Slag	Total
1971	75	70	145
1972	61	65	126
1973	26	62	88
1974	35	47	82
1975	48	41	89
1976	46	51	97
1977	85	31	116

In addition, the tin concentrates exported from Zaire result, when smelted in Spain and Belgium, in tin slags with enough contained tantalum to be commercially usable sources.

ZAIRETAIN

The Manono mine is located between the Lualaba River and Lake Tanganyika at 27°4' longitude east and 7°20' latitude south, nearly 500 km. north of the well-known copper mines near Lubumbashi and Kolwezi. The primary ore body consists of an acid-pegmatite intrusion in the inferior Kibara micaschists. The intrusion is connected to the ancient granites of the geological constituent shield which ranges in age from 900 to 1,300 million years. The Manono deposit is very large, being about 10 km. long in a SW/NE direction with two distinctive parts of 3,500 m. and 3,000 m., respectively, which are separated by a granitic zone. The width ranges from 50 m. to 700 m. and is known to be up to 100 m. deep. The pegmatite-micaschist contacts are inclined from 70 to 40 SE.

Weathering altered the upper part of the pegmatite body creating secondary eluvial deposits with a depth of 4 to 10 m. The weathered but still rocky pegmatite below this surface layer is partially fissured to a depth as great as 60 m. Further below, the deposit is solid hard-rock pegmatite, very compact and abrasive in nature. The facies of the pegmatite is not uniform with respect to texture and mineralogy. It varies from a large quartz and feldspar crystal type (microcline) to an albitic type with very fine grains. In the heavy crystal type, feldspar is more or less replaced by spodumene (lithium ore) with large crystals up to 1 m. long x 0.50 m. broad. Particular facies of greisen or allophamic pegmatite occur in some parts. Cassiterite and columbo-tantalite mineralisation are evenly distributed in the ore, but in unequal quantities and generally in small crystals (up to 3 mm.). Very important cassiterite upgradings occur in some local parts but such are without columbo-tantalite in the greisen elements of the ore body.

For the past fifty years the mining at Manono has been in the upper segments of surface laterite and weathered pegmatite and the underlying rocky pegmatite. The ore, depending on the weathered or rocky nature of the material, is either only washed

and screened or crushed for screening to sizes from 6 mm. down to 2 mm. In either case, the treated ore is then processed in the classical gravimetric fashion of jigging and tabling. As a result, mixed concentrates of tin ore (up to 60 % tin) and columbo-tantalite are collected. These first concentrates are then further treated to produce a tin ore with 70 % Sn content and the columbo-tantalite concentrate. Three principal steps are followed:

Flow through jigs and tables to eliminate quartz and feldspar sands.

First passage through magnetic separators with normal intensity to collect high-grade tin concentrates (69-70 % Sn).

Second passage through the magnetic separators at high intensity of the magnetic material left from the first passage to concentrate the columbo-tantalite to a high level.

Some typical analyses of the columbo-tantalite product are as follows:

% Ta ₂ O ₅	% Cb ₂ O ₅	% SnO ₂	% TiO ₂
31.86	36.84	1.93	1.63
31.36	37.03	1.85	1.25
31.72	37.77	1.25	1.42

The tin concentrates are smelted at the Manono tin smelter which produces a low-tin tantaliferous slag of good commercial value. The smelting process is performed in two electric furnaces (1,000 Kw and 800 Kw) in two steps:

In the first step, cassiterite is mixed with hartlingen (hard-head, an iron-tin alloy with 65 % tin content), dross, charcoal, and lime. The yield is tin metal (to be further refined) and slags containing 22 to 25 % tin.

In the second step, the slags from the first step are remelted together with a reducing agent and lime. The resulting products are hartlingen, recycled to the first step, and the tantalum-bearing slags with the tin content reduced to 1 to 1 1/2 %.

Typical analyses of the final slags are:

% Ta ₂ O ₅	% Cb ₂ O ₅	% SnO ₂	% TiO ₂
12.26	9.68	1.50	0.74
11.29	9.93	1.00	1.77

The production of tantalum source materials by ZAIRETAIN is totally dependent on tin production. Over the last few years tin mining at Manono has been trending downward due to several factors. The weathered and rocky segments of the Manono ore body have been nearly exhausted leaving only the hardrock pegmatite understructure. This very large reserve, estimated to contain more than 100,000 m.t. of tin, requires a different type of mining than has been practised in the past. Huge investment is needed and there is a question of being able to operate profitably under present conditions. Other problems involve the economic breakdown of Zaire, the upset conditions of the transportation system since the upheaval in Angola, public overspending, and the deterioration of the Zaire balance of payments on their debt.

Production by ZAIRETAIN has been as follows (in m.t.):

Year	Cassiterite 70 % Sn	Cb-Ta Concentrates	Tin Slags
1973	1,271	35	250
1974	1,045	30	186
1975	957	30	163
1976	680	30	203
1977	1,034	30	125

SOMINKI

In the Kivu area, the production of tantalite by SOMINKI is also the byproduct of tin mining. Production is out of a number of primary pegmatite deposits where the cassiterite is located in contact zones. Some secondary deposits of columbo-tantalite exist without any cassiterite but these have not been developed into production. There are three grades of tantalite produced:

	Gr. I	Gr. II	Gr. III
Ta ₂ O ₅ content	25-28 %	33-37 %	40-45 %
Cb ₂ O ₅ content	43-47 %	35-40 %	25-35 %

By subtracting the ZAIRETAIN production from the total reported Zaire production, it would appear that the output in Kivu increased from virtually no material in 1973 to about 24,000 lb. Ta₂O₅ in 1976 and then jumped quickly to about 63,000 lb. Ta₂O₅ in 1977.

RESERVES IN ZAIRE

There has been much controversy as to the size of tantalite reserves in Zaire. They have been estimated to be as high as

81.9 million lb. Ta (U.S. Dept. Interior, Bureau of Mines, « Mineral Facts & Problems », 1975). On a comparable in-ground basis a review of other sources has resulted in an estimate of 10.1 million lb. Ta_2O_5 (2,300 metric tons recoverable, T.I.C. « Bulletin », issue No. 15). If it is assumed that the ratio of recoverable Ta_2O_5

to tin will remain the same for future mining at Manono, the reserves there alone would be about 12.5 million lb. Ta_2O_5 recovered or about 20.0 million lb. in the rock. Irrespective of the estimate believed, there is no doubt that the reserves in Zaire are the largest known in the free-world.

Technical, Economic and Other Factors in the Gravity Concentration of Tin, Tungsten, Columbium and Tantalum Ores.

The following article has been extracted from a presentation made by Derek J. Ottley, Vice President of Behre Dolbear & Company, Inc. of New York City as a part of the Short Course on Gravity Separation Technology in Reno, Nevada, U.S.A. on October 14-16, 1978.

INTRODUCTION

In contrast to the steel and most base metal primary industries, where reduced production is prevalent and low prices are currently being experienced, tin, tungsten, tantalum and columbium producers are enjoying record or near record high prices.

This is an opportune time, therefore, to review concentrator processes and practices, mineral economics and other relevant aspects of the processing of ores of these metals.

PLANT CAPACITIES, ORE GRADES AND METALLURGICAL PERFORMANCE

A few more general statistics may provide some additional useful background information.

Lode type processing plants have relatively small ore throughput capacities mostly within the range of 100 to 2,000 tons per day. A few alluvial plants, particularly the tin dredge operations in Malaysia, Indonesia and Thailand, handle significantly larger tonnages of up to 1,000 tons per hour or more of solids. Hand mining and sluicing methods for tin are, however, of relatively modest tonnages.

Typical ore feed grades for lode type processing plants will fall largely within the following ranges:

Tin	- 0.30 to 1.50 % Sn.
Tungsten	- 0.50 to 1.50 % WO_3 .
Columbium	- 0.50 to 0.80 % Cb_2O_5 .
Tantalum	- 0.15 to 0.30 % Ta_2O_5 .

The grade of ore mined and processed will depend upon a number of factors generally with the lower grade ores treated in the larger capacity plants and the higher grade ores in smaller plants. Ore feed grade at which a deposit can be mined profitably is decided by the overall economics and investment policies. Factors which influence the grade of ore actually mined include the characteristics, size and location of the deposit; financial aspects — investment requirements, available capital and costs of borrowed funds; mining costs dependent on deep mining or open pit; development costs to production including costs of all auxiliary services, power supply, water, roads, tailing disposal; the amenability of the ore to treatment, — the process flowsheet, operating costs, concentrate grades and recoveries obtainable; taxes and royalty payments; metal concentrate prices and the value of the concentrate at the mine.

The recoveries of tin, tungsten, columbium and tantalum from lode ore deposits are usually poor and rarely, if ever, greater than 70%. The small scale treatment of alluvial ore, by hand and sluicing methods, may not be so high but for the bigger dredging operations as much as 90% of the recoverable tin may be recovered.

The generally low recoveries of values obtained into saleable concentrates is now a subject of the highest priority in most gravity plants processing these ores, as obviously the losses in revenue are substantial even in the smallest plants at the current high metal and concentrate prices.

ORE PROCESSING

In each orebody the mineral suite and their associations will be different, and, while there will be a great deal of similarity in the equipment used, the flowsheet details, the number, type and size of the equipment and the actual treatment conditions and results will vary considerably from plant to plant.

A process flowsheet must be worked out carefully and thoroughly for each ore, based on comprehensive mineralogical analyses and extensive laboratory and pilot scale testing using representative

ore samples. Particular attention must be paid to grinding, the primary gravity separation processes and concentrate cleaning methods.

The variability of an orebody must be taken into consideration also in the development of the qualitative flowsheet and will require the testing of samples from different levels or areas of the deposit. The major weaknesses of many gravity plant designs are attributable to insufficient consideration of the characteristics of the ore and their variation throughout the deposit and unrealistic or incomplete testing of good samples.

PLANT IMPROVEMENTS AND INCREASED PRODUCTION

Clearly the current high prices for concentrates compel all plants to give urgent attention to increasing their production and profits. This could be accomplished in a number of ways:

- expanding existing mines and processing plants;
- opening up new deposits and building more modern and efficient plants using the best available equipment, design and technology;
- retreatment of old tailing and mine waste dumps;
- improving plant recoveries and, as appropriate, concentrate grades and values.

The most economic and quickest means to increase production is to improve, if possible, present plant recoveries. Higher recoveries might also allow the profitable treatment of lower grade ore and thereby extend the life of the orebody and of the operation. Better and more efficient utilization of a natural resource is preferable to the development of new deposits. The time and capital investment necessary to bring a new deposit into production may be prohibitive and impractical to the smaller as well as the larger producers. What are the reasons and causes for the comparatively modest recoveries obtained even in the best operated plants and often for the less complex ores? Major losses are usually in slimes, of about minus 10 to possibly 30 micron size, which cannot be effectively processed by gravity methods or by flotation. These are created because of the very brittle nature of the mineral values, and aggravated by their high specific gravity.

Generally little attention is given in mining to overbreakage, and this can be important to the ore processing plant performance, especially where there are coarse mineral values which may be partly broken into fine particles during blasting.

Most of the overbreakage occurs in the primary grinding and in the middling concentrate regrind circuits. While this cannot be eliminated, there are many ways of reducing the production of slimes which might include one or more of the following:

- crushing of the ore to minus 1/4" if possible, before grinding;
- screening and separate grinding of two or more size fractions, and by multiple stages of grinding;
- the use of short length, grate discharge ball mills of slow speed, with carefully selected liners, ball size and pulp density;
- open circuit grinding with screening ahead of the mill to remove down to minus 35 mesh material;
- the use of wet vibratory ball mills for middling regrind wherein impact energy and grinding can be better controlled;
- consideration of the use of wet and, more especially, dry autogenous mills for primary grinding;
- improved operational control of the grinding circuits by the use of simple but effective process control systems and instruments for pulp density and flow measurements, ore feed rate control, and water additions;
- thickening and control of feed tonnage and density of middlings fed to the regrind circuit.

Too frequently the primary mill circuit is selected on the basis of the tonnage, grindability and product size requirements by the manufacturer or by the engineering design group with emphasis on minimizing costs rather than satisfying the process require-

ments of maximum liberation and minimal overgrinding. Clearly, cyclones alone have no place in a primary grinding circuit for classification since they cause the heavier and brittle materials already liberated to be returned in the underflow to the mill for further grinding. Cyclones can be used effectively, however, for density and flow control in conjunction with the vibratory screens to handle the cyclone underflow before grinding of the oversize, or for desliming ahead of jigs, tables, spirals or cones used as scalping units to remove free values generated by grinding. For fine sizing or classification, there is little alternative but to use cyclones. The new classifying device developed by Hukki may offer some promise and the CTS screen has had some limited success in sizing down to 200 mesh but screen wear is usually excessive.

One process, which has been successfully applied to the treatment of iron ores and to clay removal in potash flotation and other large tonnage operations, is selective flocculation of slimes and this may have great potential in gravity concentration. The essential principle is to secure preferential adsorption of a polymeric flocculant on the fine valuable mineral particles. Special chelating type polymeric flocculants have been developed for scheelite and cassiterite. The analogy of the selective action of thiol type flotation collectors for sulphide minerals has led to the development of these special polymers.

By the use of selective flocculants, the fine particles only would be flocculated and the gangue slimes remain dispersed. The flocs would settle and could be separated and directed to flotation or the fine gravity recovery circuit.

Selective flocculation appears to offer a more immediate and less costly method of fines recovery than by attempting to reduce overgrinding. A considerable amount of bench and plant scale testing may be needed however to develop fully a process for a specific ore.

The second major reason for poor mill recovery is probably the variation in the ore characteristics in terms of grade, hardness, mineral composition, liberation mesh, impurity content and other factors, such as the amount of fines, clays, talc, etc. Thorough testing and analysis of many ore samples should expose many of these variations which can then be incorporated into the mill when it is designed or space provision can be made for their later addition. Changes in an ore that have occurred since a mill was built originally can give rise to many problems and costly changes. Even when the orebody may be relatively uniform variations occur in the plant because of segregation of the crushed ore in the fine orebin and this will affect grade, ore grindability and throughput rates.

Few gravity plants have sufficient ore storage capacity for blending and feeding the mill with a more uniform ore. The screening of the crushed ore into 2 or 3 sizes for separate storage and feeding into the plant may offer further improvements in plant control and reduced variations.

It may be possible to introduce an effective ore grade and quality control system into the mine. This requires close co-operation between the mine staff, geologists and mill personnel. Metallurgical testing of stope samples may be helpful in coordinating mine production with mill throughput.

Variations in the ore characteristics will occur anyway and these can best be accommodated in the design of the concentrator to give maximum flexibility of operation and good control of each unit process in terms of solids flow rate, pulp volume and density. Surge bins, stirred tanks, oversize dewatering classifiers or thickeners between jigs and the regrind mill, ahead of each gravity tabling circuit, for middling products ahead of regrinding or retreatment, and, ahead of the slimes section, will allow much improved control and flexibility. The inclusion of reliable on-stream analysis for continuous monitoring of values in feed and tailings process flows is now a necessity and good systems are available.

Poor operation of the plant is another contributor to poor recovery, not only because of poor design and process flexibility, but because of untrained labor, labor attitudes, union regulations, etc., as well as relationships with management. Generally the labor, although untrained, has a considerable initial interest and willingness to learn and to improve their skills. It is considered most important to generate and maintain good relationships with all plant labor and maintenance personnel and to encourage their suggestions and involvement in improving the plant. Appropriate training courses are considered vital as are good communications and provision of reasonable working conditions.

There are, in many instances, refractory components of an ore which prevent in part any improvements in recovery. These may include finely disseminated cassiterite in gangue or in

sulphides and tin in chemical association with other minerals. Often, however, the losses of values and the poor recovery are wrongly classified in many plants as being of a refractory nature.

The actual manner in which losses are present in a gravity plant tailing should be determined by careful and thorough sampling and analysis of those samples, by size analysis, heavy liquid separation of the fractions, fraction assays and assays of the sink and float products, and mineralogical examination of selected products. From this basic data a program for plant improvements can be developed and implemented, and the actual sources or causes of the losses established and studied for possible correction.

A good general measure of the extent to which an ore is not being processed correctly, to show the amount of sliming and the proportion of refractory values, is to determine the size distribution of the mineral values only in the ore, final concentrate and final tailing. Clearly, the closer the sizes are together, the less is the amount of overbreakage or sliming of values that has occurred during processing.

Many smaller plants and some larger ones have insufficient or inadequately experienced metallurgists to establish effectively the causes of losses in a plant and more especially to know how to develop and carry out an effective program for improvements. Few plants have adequate sampling and testing facilities of their own, such are most important and can be readily justified. The use of government sponsored central test facilities and of independent metallurgical laboratories is in many countries quite extensive but there is need for more effective use, requiring that the test program, schedule and costs be well defined, coordinated and monitored.

There are a number of other essentially non-technical factors, which are also deterrents to plant improvements. Some of these might be mentioned briefly and include:

- 1) high import duties and currency restrictions which may prevent the use of imported equipment or encourage the production and use of inferior or unsuitable equipment and locally made wear parts;
- 2) plant staffs, not economic or profit oriented, who have difficulty in the preparation of sound financial justifications for changes in or additions to a plant which will satisfy management and who can be assured of successful completion if financial approval is given;
- 3) tax and royalty regulations and payments which are prohibitively high in some countries offer no incentive for investment.

CONCLUSIONS

The substantial increases in the prices for tin, tungsten, columbium and tantalum concentrates have helped many previously marginal operations to become very profitable.

Changes in process practices and the introduction of new and better equipment have been slow, even by some of the bigger and more prosperous companies. Some processes have become obsolete because of the much higher mineral values.

A great deal has been done by the International Tin Council (ITC) to promote technological development of the exploration, mining, processing and smelting and refining of tin ores by the organisation of international symposia and by the dissemination of information to member companies and countries.

This is now being done also by the recently formed Primary Tungsten Association (PTA) and by the Tantalum Information Center (TIC). It is suggested, however, that more might be done to improve ore processing plants through the collection of more detailed technical and operational data from the plants of contributing members; through voluntary or sponsored surveys and analyses; by more specialised technical and economic oriented symposia; by other small and general meetings on specific topics such as new equipment and processes; and by on-stream analysis, sampling, metallurgical testing and mineralogy. The rewards can be substantial.

T.I.C. MEMBERSHIP

During the Tenth General Assembly on 13th October 1978 the following company was elected to membership of the T.I.C.:

Bhuket Union Thai Minerals Co., Ltd.,
115/1 Bhuket Road,
Bhuket, Thailand.