TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN | ISSUE No 35 | SEPTEMBER 1983 | THIRD QUARTER

Autumn meeting

The Twentieth General Assembly of the Tantalum Producers International Study Center will be held at 9.30 a.m. on Wednesday November 2nd 1983, in the conference room of the International Association Centre, 40 rue Washington, 1050 Brussels.

The formal assembly to carry out the business of the association will be followed by presentations :

Treibacher — A unique enterprise
by Mr Otwin Pilgram, Treibacher Chemische Werke AG

Chip capacitors, with emphasis on tantalum
Dr W. Schnabel, Manager, Electrolytic Capacitor Development, Siemens AG

Tantalum and its alloys as engineering materials for the '80's
by Mr Reinhard Deil, Group Managing Director, Murex Ltd.

The role of the Metal Bulletin in tantalite pricing
by Mr David Gilbertson, Editor, Metal Bulletin

Coffee will be available before the assembly, from 9 a.m., and lunch will be served after the meeting : delegates will be the guests of the T.I.C.

The T.I.C. now has its office on the second floor of the International Association Centre, and delegates will be able to take this opportunity to see the facilities there. We should like to remind readers of the Bulletin that our telephone number is (02) 649.51.58; this is the individual telephone of the T.I.C. and it is equipped with an answering machine which will take your message when the Secretary is not in the office. There is also a telex facility in the Centre : the number is 65080 INAC B, and it is helpful if messages are prefaced with the name of the T.I.C.

The Centre offers a comfortable salon for the use of visitors before and after the meeting. There are also small conference rooms available, suitable for discussion groups of about a dozen people : delegates who would like to reserve such a room in the afternoon should contact the Secretary, who will arrange this.

Further information on the General Assembly and the T.I.C. may be obtained from the Secretary, T.I.C., rue Washington 40, 1050 Brussels, Belgium.

T.I.C. TWENTIETH GENERAL ASSEMBLY

The Twentieth General Assembly of the T.I.C. will be convened at 9.30 a.m. on Wednesday November 2nd 1983 at 40 rue Washington, 1050 Brussels.

The agenda will be :

1. **Presidential Address.**
2. **Minutes of the Nineteenth General Assembly (held on May 24th 1983 in Penang, Malaysia).**
3. **Applications for membership.**
4. **Accounts for January 1st 1983 to June 30th 1983.**
5. **Report of the Executive Committee.**
6. **Statistics for production and processing.**
7. **Statutory elections.**
8. **Twenty-first General Assembly.**
9. **Other business.**

The formal business of the association having been completed, presentations will be given by Mr Otwin Pilgram of Treibacher Chemische Werke, Dr W. Schnabel of Siemens, Mr Reinhard Deil of Murex and Mr David Gilbertson of the Metal Bulletin.

Further information concerning the meeting, and the T.I.C., may be obtained from the Secretary of the T.I.C., 40 rue Washington, 1050 Brussels, Belgium.

Letter from the President

Well, the Penang meeting was another excellent opportunity to meet fellow members and exchange ideas. Our sincere thanks to the three host companies for making the meeting possible.

The T.I.C. is continuing to grow in membership numbers and continually reviews its activities to see if it can improve its service to members. In this respect a number of issues can be raised here so that members can formulate an opinion prior to the November meeting.

The Tantalum Producers International Study Center was the name chosen nearly ten years ago when a group of producing companies initiated the move. This is no longer applicable today, as our 65 member companies represent all sections of the tantalum industry. Consideration should be given to deleting the word Producers and retaining the name Tantalum Information and Study Centre (T.I.C.).

As President of the T.I.C. it is especially encouraging to have active participation by members of the Executive Committee and I am pleased to say that after the Penang meeting Mr Rod Tolley, representing the tin slag producers, and Mr Carroll Killen, representing the capacitor industry, agreed to join the Committee. Even with a full complement of Committee members there is an increasing workload for our Secretary in Brussels. The members are asked at this point to think about the type of services they would like to receive as members of the T.I.C. and if this can be clearly identified it may be time once again to consider employing another part or full-time employee for the Brussels office.

In the meantime the services that are being provided are increasing even with the limited resources available. As a result of the questionnaire to all members prior to the Nineteenth General Assembly we include in this issue a tabulated break up of the membership by product type within the industry. This is a first step to assist members to understand the products and services provided by our industry and it is the T.I.C.'s intention to build an information file on each member company, to be kept in the Brussels office library. Any member companies that produce brochures on their company activities, annual reports or sales material would be advised to include the Secretary of the T.I.C. on their mailing list so that the file on their companies' products can be kept up to date.

The issue of statistics is fundamental to the services provided by the T.I.C. Collection of statistics is progressing steadily. Producer statistics are now provided on a regular basis within an acceptable time limit of thirty days from receipt of the questionnaire. Requests for processor statistics are now being sent out on a regular basis, but replies are not yet received within the time required. Publication of statistics benefits all members of the industry but the benefit diminishes proportionally to the time to which the statistics apply. I urge all delegates of member companies to appoint a single person in their organisation to be responsible for filling out the statistical form and returning it to Price Waterhouse within the requested time. It is better to receive close approximations of the numbers early than to receive exact numerical data late. Remember one late return will delay publication of all data collected, under the current rules for reporting established at the Nineteenth General Assembly. Your urgent co-operation is requested.

The T.I.C. has commenced building a library of information on tantalum. Particularly relevant are new publications from any source written on any section of the industry. The T.I.C. will trace these publications and where necessary translate the document, and where possible make copies available to members. A list of publications currently available is included in this issue and will be updated from time to time. The Editor will be asked to summarise the most important of these publications in review form in future issues of the Bulletin. The T.I.C. library will be available to all members and anybody wishing to make use of the office or library facilities in Brussels is asked to make the necessary arrangements with the Secretary.

The Twentieth General Assembly will be held on 2nd November and we have arranged a speaker programme including talks to be given by Otwin Pilgram from Treibacher, Reinhard Deil from Murex, W. Schnabel from Siemens and David Gilbertson from London Metal Bulletin. This meeting will be an excellent opportunity for members to inspect the T.I.C. facilities and to discuss some of the issues raised, or indeed any ideas that members may wish to raise regarding an improvement in the services offered or to be offered by the T.I.C.

I look forward to seeing you all on the 2nd November.

Classification by industry section and product type

Company T.I.C. members :	1. Producers, producing	Tantalite concentrates	Columbite or struverite concentrates	Tin slags containing more than 10 % Ta_2O_5	Tin slags containing less than 10 % Ta_2O_5	Scrap	Other	2. Processors, producing	Synthetic concentrates	Scrap	Ta_2O_5/K_2TaF_7	Powder/anodes	Ingot (Unworked metal)	Mill products	Ta-carbides	Alloy additives/Vacuum Melt Grade Ta	Other	3. Fabricators, producing	Capacitors	Cemented carbides	High temperature alloys	Mill product equipment	Other	4. Consumers, producing	Electronic and communication equipment	Metal cutting and grinding equipment	Jet engines	Aerospace and military equipment	Chemical industry equipment	Other	5. Traders	Producer products	Processor products	Scrap
B.E.H. Minerals			X																															
Bhuket Union Thai Minerals		X	X	X																												X		
Componentes Electronicos																			X															
Derby and Co.																																X	X	X
Minera del Duero		X																																
Fansteel											X	X	X	X	X	X				X		X												
Greenbushes Tin		X		X							X																							
W.C. Heraeus													X	X															X					
Intersteel Comercio Exterior		X																														X	X	X
Kennametal										X		X		X	X	X																		
Lien Metals											X	X																						
Makeri Smelting					X																											X		
Malaysia Smelting					X																													
Mallinckrodt											X						X																	
Mamore Mineracao e Metalurgia					X																													
Metallurg (part of group)															X																			
Metallurgical Industries						X				X						X																		X
Minex			X																															
Norore																																X	X	
N.R.C.										X	X	X	X	X		X																		
Centro Minero de Penouta		X																																
Pilgan Mining		X																																
Sabemin																																X		
Samincorp																																X	X	X
Sandvik																				X														
Siemens																			X															
Sominki		X																																
Somirwa		X			X																													
Sprague Electric																			X															
Hermann C. Starck Berlin									X	X	X	X	X	X	X	X	X																	
S.T.C. Components																			X									X						
Straits Trading																																X		
Tantalum Mining Corporation of Canada		X																																
Associated Mines (Thailand)		X	X	X																														
Thailand Smelting and Refining				X	X																													
Thermo Electron															X																			
Treibacher Chemische Werke									X		X				X		X																	
Union Carbide																			X															
Vacuum Metallurgical													X	X		X					X													
Zairetain		X		X	X																													
Alfred H. Knight International	Independent international samplers, surveyors, analytical chemists, assayers and metallurgical consultants																																	

Company Non-members :	1. Producers, producing	Tantalite concentrates	Columbite or struverite concentrates	Tin slags containing more than 10 % Ta_2O_5	Tin slags containing less than 10 % Ta_2O_5	Scrap	Other	2. Processors, producing	Synthetic concentrates	Scrap	Ta_2O_5/K_2TaF_7	Powder/anodes	Ingot (Unworked metal)	Mill products	Ta-carbides	Alloy additives/Vacuum Melt Grade Ta	Other	3. Fabricators, producing	Capacitors	Cemented carbides	High temperature alloys	Mill product equipment	Other	4. Consumers, producing	Electronic and communication equipment	Metal cutting and grinding equipment	Jet engines	Aerospace and military equipment	Chemical industry equipment	Other	5. Traders	Producer products	Processor products	Scrap
Fulmer Research Institute (U.K.)																														X				
Fundacao de Tecnologia Industrial (Brazil)										X		X	X	X							X													
Gemin (Brazil)																																X	X	
Inabata (Japan)																																	X	
Key Metals & Minerals Engineering (U.S.A.)		X	X		X	X																												
Mallory Capacitor (U.S.A.)																			X															
Oxford Airco (U.S.A.)																							X											
Powell Metals & Chemicals						X	X			X					X	X	X															X	X	X
Shin-Etsu Chemical (Japan)																							X		X				X					
Tekelec Airtronic (France)																			X						X			X						
Titanium International (U.K.)																																X		
Varian Specialty Metals (U.S.A.)													X			X									X									
Welders (Belgium)																													X					

U.S. Stockpile purchases Tantalum

On July 5, 1983, the General Services Administration (G.S.A.) of the United States Government announced that it would purchase 305,250 lb. of tantalum pentoxide in natural mineral concentrate form for the U.S. Stockpile. Originally it was intended that the purchase offer would be limited to sources in the nineteen signatory countries of the international procurement code implemented under the Trade Agreements Act of 1979. This restriction would have prevented solicitations of bids from some of the major tantalum-producing countries such as Brazil and Australia.

On July 29, however, G.S.A. amended its solicitation to allow bids from non-signatory countries, having obtained verbal approval from the U.S. Trade Representative as required by law. In addition, the deadline for bidding was extended from August 23 to August 30 and the delivery period was increased from six months to one year.

The total purchase of 305,250 lb. of tantalum oxide will be made in increments of 61,050 lb. (50,000 lb. of contained tantalum). The material is to conform to the chemical and physical requirements of Grade 1 as specified in the National Stockpile Purchase Specification -113a which requires a minimum of 25 % Ta_2O_5, a minimum of 55 % combined Ta_2O_5 and Cb_2O_5, a maximum of 6 % each of TiO_2 and SnO_2 and a maximum of 0.01 % antimony. This specification probably precluded the supply of artificial concentrate as the Schedule specifies "Natural mineral and concentrate". Furthermore, due to the specifications, tin slags and Tanco materials are also probably excluded.

The U.S. Stockpile has, at present, about 1.4 million pounds of contained tantalum in concentrates against an objective of 8.4 million pounds. The presently planned procurement, if obtained in its entirety, will therefore represent only 3.5 % of the quantity needed to reach the objective. Due to the time required to finalize a contract and the provision that "deliveries shall not start before 60 days after the effective date of the contract", it is probable that all of the material will be delivered within 1984.

If G.S.A. were purchasing tantalite, per se, without the very restrictive specification, the delivery of 305,000 lb. in 1984 would have little effect on the current stability of the tantalum materials market. The recent T.I.C. Study ("Review of 1982 Tantalum Results and Updated Industry Outlook") shows that at the end of 1982 producers held "as much as one million pounds of inventory" and processors held working inventories of about 4.64 million pounds. Even though these combined inventories may be reduced by as much as one-half million pounds in 1983 ("T.I.C. Tantalum Production and Shipments", T.I.C. "Bulletin", issue no. 34), combined inventories at the beginning of 1984 will still be well over five million pounds. A reduction of 305,000 pounds would have minimum effect and would leave the ratio of inventories to current processor demand well over two to one. Historically, processors have not aggressively pursued raw material purchases until that ratio drops to the range of 1.4 to 1.7 (T.I.C. Study).

With the restrictive specification, however, a different market condition exists. There probably is limited material in existing inventories that will meet this specification, a condition which G.S.A. already recognised when they extended the delivery time to twelve months. Some of the inventory which does meet the specification will probably be held in lots too small to meet the G.S.A. minimum delivery quantity of 61,050 lb. It would appear, therefore, that some of the material will have to be newly produced. Since it is unlikely that any producer will be interested in supplying material below cost, it is probable that offers received by G.S.A. will be at prices about the current publicly quoted price for tantalite. It is the general consensus in the industry that the published prices reflect small lot liquidations and do not truly reflect the value of newly produced material.

It can be expected, therefore, that the effect of the G.S.A. tender will be :

1. G.S.A. will have to decide whether to purchase the whole 305,000 lb. or only a portion thereof.
2. The published market prices will probably increase to reflect the prices quoted to G.S.A. and, thereby, be more consistent with the producer value of tantalite.
3. The stability of the market will be unaffected, even if G.S.A. does make a purchase, as the production of new material to supply G.S.A. will not alter the current inventory condition in the industry nor affect the current supply-demand condition of the market.

Furthermore, it seems likely that G.S.A. will have to alter their purchase specification to accept a broader range of material if they seriously desire to acquire significant amounts of material for the Stockpile. The total world reserves of material which can be mined to meet the Grade 1 quality without extra processing are probably insignificant compared to the total Stockpile acquisition objective. Any extra processing to meet the restrictive specification will obviously increase the cost of production. Therefore, G.S.A. would always be faced with receiving quoted prices above the currently published market prices. If such higher quoted prices are construed to be "disruptive" to the market in the context of the law, G.S.A. will forever be prevented from buying any appreciable amount of tantalite for the Stockpile.

T.I.C. tantalum production and shipments

The T.I.C. data for the production and shipment of tantalum-bearing concentrates and tin-slags for the first two quarters of 1983 are as follows, with the total production and shipments for 1980, 1981 and 1982 for comparison :

(figures given in lbs. Ta_2O_5 contained)

	Slags	Concen-trates	Total
1980			
Production	1,383,704	792,528	2,176,232
Shipments	1,589,729	728,480	2,316,209
1981			
Production	1,228,246	926,241	2,154,487
Shipments	1,020,598	738,628	1,759,226
1982			
Production	1,210,140	685,845	1,895,985
Shipments	957,802	442,184	1,399,986
1983 - 1st quarter			
Production	304,840	87,228	392,068
Shipments	125,003	75,684	200,687
1983 - 2nd quarter			
Production	303,398	51,497	354,895
Shipments	7,100	43,844	50,944

For the first quarter of 1983, 25 out of 29 companies reported, and for the second quarter 22 out of 29 companies reported.

Processors' shipments

(figures given in lbs. tantalum contained)

1981			1,755,139
1982			
	1st quarter	416,112	
	2nd quarter	443,690	
	3rd quarter	298,192	
	4th quarter	305,856	
	Total		1,463,850
1983			
	1st quarter	N/A	
	2nd quarter	443,833	

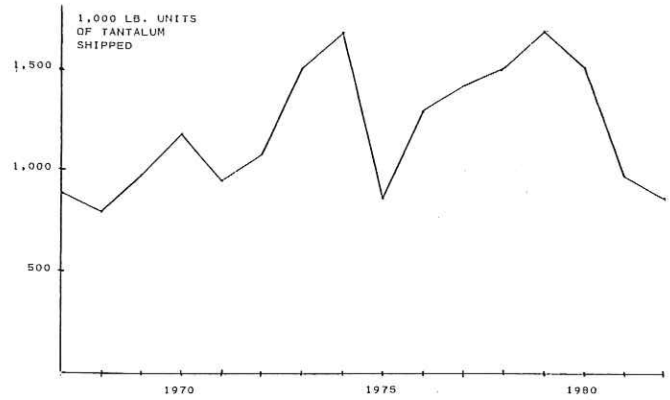
For the first three quarters of 1982, 16 out of 16 companies reported, for the fourth quarter of 1982 16 out of 17 companies reported. For the second quarter of 1983 16 out of 19 companies reported.

1982 U.S. shipments of tantalum and columbium products

The available data for shipments of tantalum products by the producers in the United States in 1982 shows a decrease from 1981 but seems to indicate clearly that the recession in the tantalum industry has bottomed out :

Product	*1978*	*1979*	*1980*	*1981*	*1982*
TANTALUM					
Oxides and Salts	38.2	35.4	48.7	50.7	36.5
Alloy additive	4.4	23.7	8.1	—	31.7
Carbide	116.9	190.1	125.7	137.2	82.2
Powder and anodes	840.0	928.2	852.9	520.2	451.1
Ingot	7.2	6.6	23.0	7.1	16.7
Mill Products	321.9	365.2	318.8	196.7	168.0
Scrap	184.1	151.0	130.9	72.7	94.5
Other	2.1	—	1.7	—	—
Total	1,514.8	1,700.2	1,509.8	984.5	880.7
% Change	6.8	12.2	(11.2)	(34.8)	(10.5)
COLUMBIUM					
Compounds	1,611.0	1,627.8	1,066.6	632.2	n.a.
Metal	223.7	329.5	344.7	260.5	n.a.
Miscellaneous	12.5	64.2	18.5	20.5	n.a.
Total	1,847.2	2,021.5	1,429.8	913.2	n.a.
% Change	71.3	9.4	(29.3)	(36.1)	—

The total quantity of product shipped almost dropped to the low level of 1975 (865,000 lb. Ta). The total decline from the peak in 1979 is 48.2 % which shows the recessional effect to be almost identical to that from 1974 to 1975 when the decline was 48.5 %. The sensitivity of the tantalum market to recession is certainly apparent when the total U.S. shipments are reviewed for the past 16 years :



The maturity of the tantalum market appears to be reflected by the fact that the two peaks during the past decade are almost identical, and so are the low points. Without new applications, tantalum may have passed its peak and be approaching the down-side of the characteristic mature-market curve.

The bottom-point has probably been reached. The comparatively mild decline of 10.5 % from 1981 to 1982 (34.5 % from 1980 to 1981) indicates that consumer inventories have been adjusted downward and that future purchases will be based upon actual consumption. The economic indications are that the recession has bottomed and, accordingly, there is a probability that demand will increase somewhat in 1983.

Capacitor powder shipments continued to decline, decreasing 13.3 %, and returning almost to the level of 1971 (398,000 lb.). Th does not reflect, however, a comparable decline in unit capacitor sales as the average CV-rating now used is three to four times greater than it was in 1971.

The true state of the carbide market is clear in 1982 negating any opinion that the slight increase in 1981 was a favorable sign. Carbide shipments have dropped to only 43 % of the 1979 peak. Significant recovery in 1983 is considered doubtful.

The reappearance of additive alloy shipments in 1982, after none in 1981, reaffirms this application of tantalum as a growing use. The 31,700 lb. shipped is the largest quantity of prime material consumed during the last ten years.

Other market segments seem to have stabilized.

As further information about the conditions of the U.S. market in 1982 becomes available, this article will be supplemented in future issues of the "Bulletin".

Vertical integration in the tantalum industry by the Metallurg Group

The following paper was presented by Dr. G. Duderstadt of Gesellschaft für Elektrometallurgie at the Nineteenth General Assembly of the Tantalum Producers International Study Center held at Penang, Malaysia on May 24, 1983. The many excellent photographs projected during the presentation have been omitted because of space considerations.

The Metallurg Group of companies is one of the world's foremost producers and suppliers of ferrous and non-ferrous metals, alloys and chemicals. Among these commodities, tantalum products play an important role.

The tantalum product line encompasses the whole range of products such as tantalum and niobium oxides in various qualities, tantalum and niobium carbides, tantalum and niobium metal and tantalum capacitor powder. Production is concentrated in five plants of the Group : GfE's Nuremberg and Elektrowerk Weisweiler plant, London and Scandinavian Metallurgical Company's Rotherham plants, Shieldalloy Corporation's Newfield plant and, last but not least, Metallurg's Fluminense plant in Brazil.

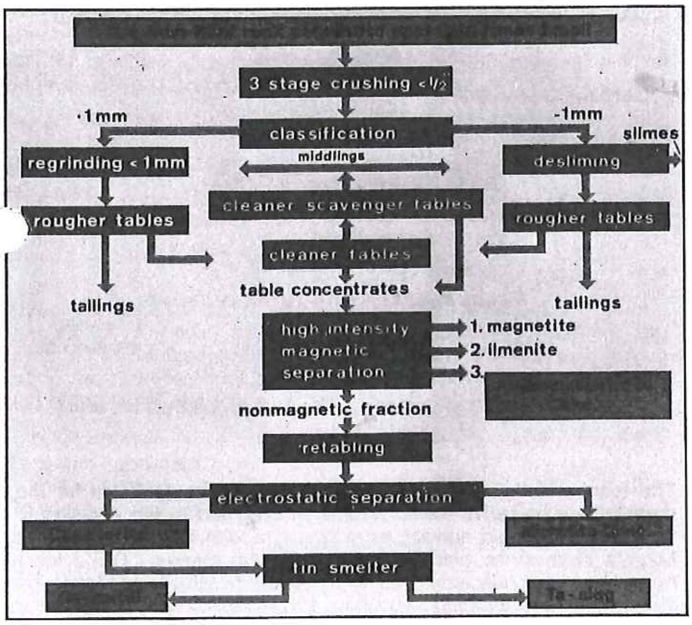
The importance of secured long range raw material supply has long been considered a vital part of such a production line with the consequence that the Group is today a completely integrated tantalum producer. Its efforts on the raw material side are concentrated in two directions : (1) the recovery of tantalite raw materials at its Mibra mines owned by Companhia de Estanho Minas Brasil in the Nazareno area in the Sao Joao del Rei region, about 300 km. northwest of Rio de Janeiro in the state of Minas Gerais, and (2) the production of synthetic tantalum concentrate from low grade tin slags at GfE's Elektrowerk Weisweiler plant.

MINING

Mibra maintains several open pit operations for recovery of microlite, columbotantalite and cassiterite from hard rock and weathered pegmatite. The region between Sao Joao del Rei and Nazareno, in which Mibra's mines are located, is part of the Pre-Minas Series (lower Pre-cambrian) represented by a suite of granite-gneiss rocks. Two types of pegmatite can be identified : one with and one without spodumene. Both types are mineralized with columbotantalite and minor associated minerals. Ore bodies differ in size, shape, grade and degree of decomposition. The weathered pegmatite area of Volta Grande carries cassiterite and columbotantalite as tantalum bearing minerals while the weathered pegmatite area of Fumal carries microlite and spodumene.

About 600 m.t. of ore per day are mined by open pit methods. Drilling and blasting are necessary for hard pegmatite. For semi-decomposed and soft pegmatite, bulldozer operation is sufficient. Gravel pumps are used in the alluvial-colluvial deposits. Ore transportation between the mines and the nearby ore-dressing plant is done by motor scrapers and trucks. All three deposits are located whithin a distance of 2 to 3 miles of each other.

For the recovery of tin and tantalum/niobium minerals, the as-mined ore undergoes a series of mineral dressing steps :



The process involves a series of standard upgrading operations resulting finally in the recovery of several tantalum-bearing minerals :

Product	*Composition*
Medium Grade Tantalite	min 30 % Ta_2O_5; 60 % C.O.
Microlite	45-55 % Ta_2O_5 5- 7 % Nb_2O_5
High-Grade Slag	30-45 % Ta_2O_5 3- 7 % Nb_2O_5

Apart from these tantalum products, cassiterite is also recovered and processed to tin metal in electric furnaces at Fluminense, generating the high-grade tantalum slag. The capacity of the tin smelter is approximately 1,500 tons per year, a further smelting facility with a capacity of 700 tons of tin being available at Mibra.

Depending on the grade, the capacity of the total mine operation is 75,000 to 100,000 lb. Ta_2O_5 recovered in the various forms. On the basis of proven reserves, the mine can operate for at least five years, while probable and inferred reserves will extend it even more.

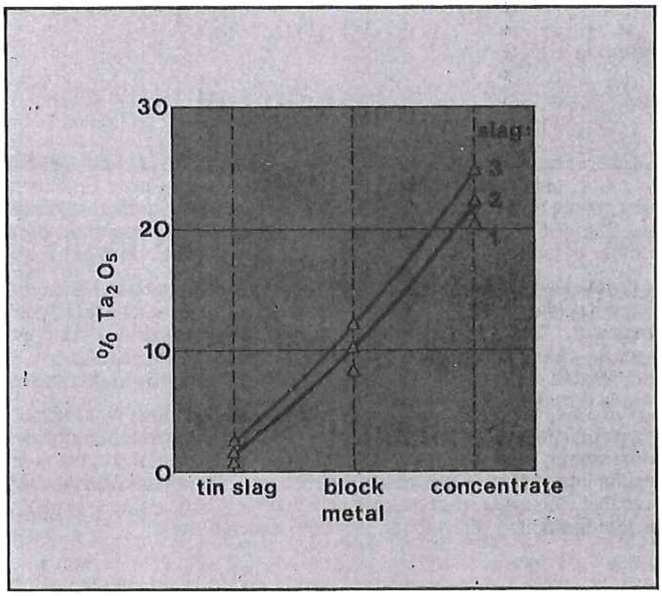
PROCESSING TIN SLAGS

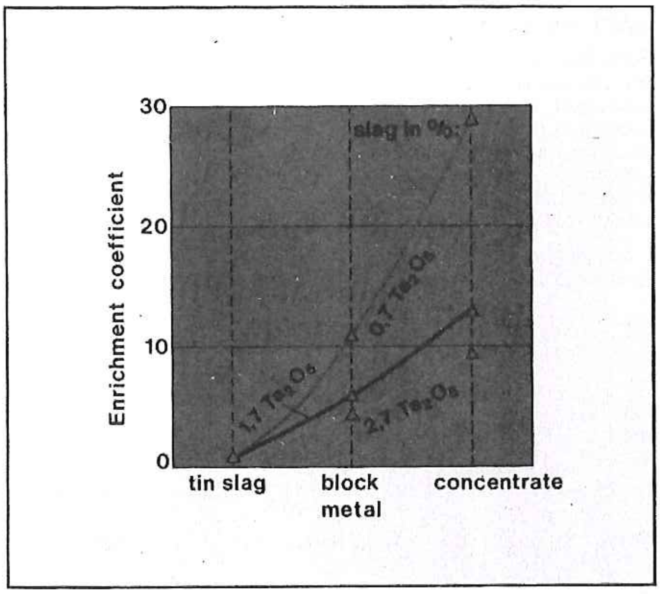
For the production of synthetic tantalum concentrates, efforts at our Weisweiler works were directed from the beginning on the processing of low-grade tin slags primarily generated at tin smelters in Thailand and Malaysia. Typical compositions of such tin slags are :

Tin Slag (% cont.)	*1*	*2*	*3*
Ta_2O_5	0.7	1.7	2.7
Nb_2O_5	1.0	2.2	2.7
FeO	19.0	16.9	12.8
WO_3	2.0	2.0	1.3
P_2O_5	0.6	0.7	0.5
SnO_2	1.0	0.8	0.8
Cr_2O_3	0.2	0.3	0.2
MnO	0.6	0.9	1.8
TiO_2	6.7	9.0	11.3
SiO_2	27.8	25.0	24.6
Al_2O_3	9.3	11.3	8.9
CaO	21.7	20.9	20.3
MgO	5.6	2.4	2.1

Apart from these low-grade slags, higher-grade slags of other origin with Ta_2O_5 contents as high as 8 % have also been processed. The process for enrichment involves several partial reduction steps in low-shaft electric arc furnaces and intermediate reduction steps. At our Weisweiler works, furnace sizes range from 1 megawatt to 24 megawatts and thus offer an excellent basis for a competitive operation in this field.

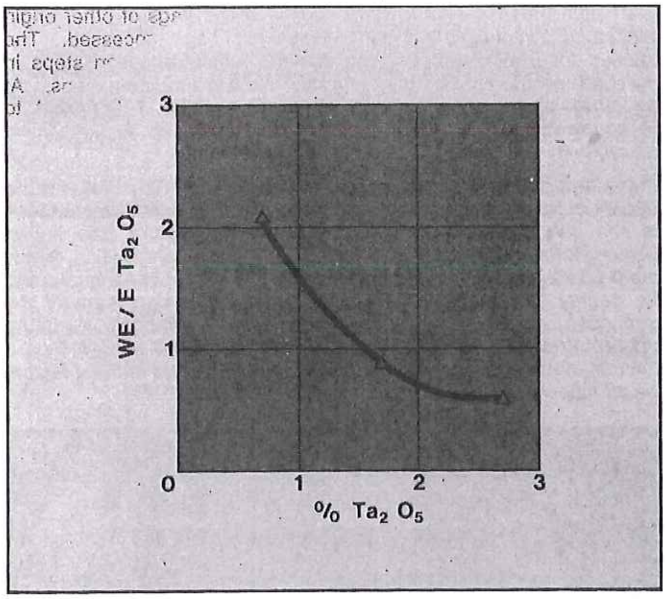
The composition of these slags, in particular the TiO_2 content, the amount of reducible oxides and the basicity, are of special importance for the concentrate production. The most important step is the recovery of a block metal of high quality as the composition of this intermediate product governs the quality of the final concentrate and the degree of enrichment. It also carries the major share of the production costs. The changes in product composition during processing and the final Ta_2O_5 content that can be achieved as a function of the starting Ta_2O_5 level and the related enrichment factors are as follows :





The standard synthetic grades produced at the Weisweiler works have a Ta_2O_5 content of 20 % to 25 % and a Nb_2O_5 content normally somewhat above this level.

It is obvious that such a discussion would be incomplete without reference to the economics. Apart from the Ta_2O_5 level, the TiO_2 content plays a major role. On the other hand, cost factors such as transport, weighing, assaying, energy, reducing agents, slag additives, etc. are more or less constant per ton of slag. Furthermore, the tantalum recovery does decrease with decreasing Ta_2O_5 starting level. To counterbalance such cost factors and to ensure a commercially viable operation, GfE has adapted a series of electric furnaces ranging from one to six megawatts which allows the production of block metal in size up to fifty tons. Depending on slag composition, the melting time per block can vary from ten to twenty days. Without going into the details of the economics of such an operation, the relationship between costs per unit of Ta_2O_5 in the final concentrate and the starting level of Ta_2O_5 in the slag is illustrated schematically :



It is obvious that one would not today touch such low-grade slags with less than 2.5 % Ta_2O_5, but the exact borderline is dependent on a number of factors.

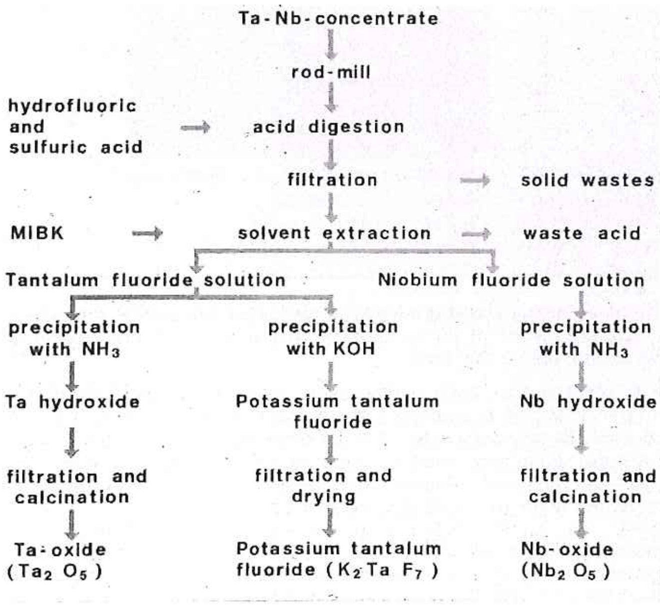
At the Weisweiler works, a mixing house provides automatic charging of the tin slag, reducing agent and slag forming additives. A six megawatt furnace has been particularly designed for the process. Handling of the fifty ton block metal is a special problem and, for this operation, we employ a pneumatic crusher ideally suited for this purpose.

It is obvious that our experience in ferro-alloy production, in particular ferrochrome, over several decades, was instrumental for the successful integration of this new product line. It can easily be derived from this discussion that these facilities offer a considerable capacity for the production of synthetic tantalum concentrates.

PROCESSING TANTALUM

The tantalite/microlite ores and synthetic concentrates from the Mibra and Weisweiler operations serve as a raw material feed for the liquid-liquid tantalum/columbium solvent extraction line at GfE's Nuremberg plant. Part of the resulting Ta_2O_5 and Nb_2O_5 products are shipped to the processing plants of Shieldalloy Corp. and London Scandinavian Metallurgical in the United States and the United Kingdom, respectively, for the manufacture of tantalum carbide and tantalum alloys.

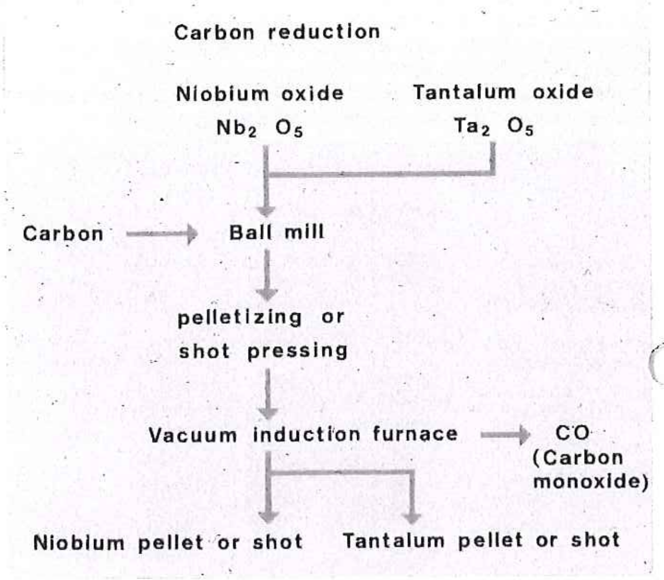
A schematic flow-sheet of the solvent extraction line at GfE's Nuremberg plant is given :



This product line, which produced the first K_2TaF_7 commercially in 1952, has undergone several modification and expansion programs in the intervening years. The latest was during 1978 to 1982 to increase the capacity of the digesters and the Ta_2O_5/Nb_2O_5 output. The tantalum products manufactured today at this plant and the applications of the chemical compounds are as follows :

Product	*Application*
Ta-oxide CP	Carbides, alloys
Ta-oxide EG	Electro ceramic devices
Ta-oxide OG	Optical glasses and covers
Nb-oxide CP	Carbides, alloys
Nb-oxide EG	Electro ceramic devices
Nb-oxide OG	Optical glasses and covers
Potassium tantalum fluoride	Tantalum metal powder

Another production route that has gained a certain importance is the manufacture of tantalum and niobium shot for metallurgical application by carbon reduction of tantalum and niobium oxides under vacuum :



The requirement for tantalum and niobium oxides in Brazil for the manufacture of Ta/Nb metal carbide recently led to the decision to install a liquid-liquid solvent extraction line with limited capacity at Mibra's Fluminense plant to serve the local market. GfE's technology has been fully employed for the layout which encompasses the following steps : grinding, digestion, solvent extraction, precipitation and calcining of the tantalum and niobium oxides. The quality of these products makes them fully applicable for the manufacture of related metal carbides. The capacity of this plant is rated presently at 60 tons of raw material feed per year and can be easily expanded if the need should arise.

At the plants of LSM and SC, emphasis has been placed upon the installation of high technology equipment, such as high-vacuum furnaces, to enable the production of the solid solution carbides with low gas contents, essential to the manufacture of good quality metal-working grades of hardmetal. These furnaces, with bodies up to 300 litres capacity, are capable of temperatures up to 2300 °C and pressures down to 10^{-4} torr. Close attention is paid to factors such as the nature of the starting materials, the temperature of the reaction and the number of production steps employed in order to ensure that optimum quality is achieved.

The raw materials employed at these two plants are mainly the tantalum and niobium oxides from GfE's Nuremberg plant. The oxides are milled with the required amount of carbon prior to the vacuum furnace treatment which includes the following steps : degassing, heating, reaction, cooling, the latter partly under helium to decrease the time during this phase. Mixed crystals of TaC/NbC behave similarly to niobium-free (or low Nb) TaC. Increasing Nb content, however, requires higher sintering temperatures and longer vacuum sintering conditions to obtain the correct carbon balance and control of the under-carburized phases. Most of the mixed carbides produced are tailored to the individual needs of the customers. Basic tantalum containing powders are produced today by both LSM and SC in various grain sizes, normally in the 1-2 and 2-3 micron ranges and in various grades identified by their niobium content. Many triple and quaternary carbide powders are also produced, products which are gaining more and more importance.

In summary, the tantalum raw material activities at the Group's Mibra mines and Weisweiler works feed the solvent extraction lines of GfE and Fluminense for the production of a whole series of tantalum chemical compounds and metal products. Some of the tantalum oxide is converted into tantalum carbide at the Group's production facilities at Rotherham and Newfield.

Japanese tantalum consumption

The information in this article has been collected from a number of sources during a visit to Japan by the Editor during May 1983.

Consumption of tantalum products in Japan during the past four years has been :

(unit : m.t.)	*1979*	*1980*	*1981*	*1982*
Tantalum powder - Cap. Gr.	101.0	87.0	66.0	58.0
Tantalum powder - Met. Gr.	3.7	5.8	5.0	2.4
Ta Mill Products	37.4	36.9	28.3	26.2
Ta Carbide (Ta cont.)	36.4	30.0	28.0	27.0
Ta Oxide (Ta cont.)	15.7	12.4	7.3	11.0
Total	194.2	172.1	134.6	124.6
Growth rate	+ 33.2 %	− 11.5 %	− 21.8 %	− 7.4 %

The rapid decline which the tantalum market experienced in 1980 and 1981 appears to be levelling off although a continued decline of 5 % to 7 % has been forecast for 1983. The major part of the 1982 decline was experienced in capacitor powder use. The electronic industry use of tantalum, however, continues to be the most significant segment, its proportion of the total remaining close to two-thirds :

Market segment (% of total)	*1979*	*1980*	*1981*	*1982*
Electronics	67	68	67	64
Industrial	6	8	6	5
Cutting tools	19	17	21	22
ens	8	7	6	9
	100	100	100	100

The consumption of capacitor powder in 1982 was about 6 % greater than the forecast made in mid-1982, possibly indicating an effect from lower prices in the second half of the year. The use per device produced, however, continued to decline, reflecting a higher proportion of the high CV/gram rated powders :

	1979	*1980*	*1981*	*1982*
Tantalum capacitors (million pieces)	1093	1332	1290	1371
Powder ratio (g./unit)	0.096	0.070	0.055	0.042

Forecasts indicate that the powder ratio will drop even further in 1983 to the range of 0.036 to 0.038 grams per unit. Even though a growth rate in tantalum capacitor production from 7 % to 9 % is forecast, the result will be a decrease in actual powder consumption of about 6 % to 7 %.

Domestic production in Japan of tantalum products reached a peak in 1979, supplying 121.7 m.t., 62.6 % of total consumption. Although domestic production through 1982 has dropped to 93.0 m.t., a 24 % decline, its share of the total market has increased to 75 %. As a result, the Japanese processors have not experienced as drastic a decline in their operations as the processors in Europe and the United States. Furthermore, imports from these foreign producers into Japan have declined by 56 % from 1979 through 1982.

Source (unit : m.t.)	*1979*	*1980*	*1981*	*1982*
Imports	72.7	57.7	30.0	31.6
Domestic production	121.7	114.4	104.6	93.0
Total	194.4	172.1	134.6	124.6
% produced in Japan	62.6	66.5	77.7	74.6

A rough forecast indicates that the tantalum industry expects a further drop in the total consumption to about 115 m.t. (Ta contained) in 1983, approximately 10 m.t. less than in 1982. Most of the decrease will again be in the products for the electronic industry.

Production of tantalum containing slags at Thaisarco

The following article has been written from a presentation made at the Nineteenth General Assembly of the Tantalum Producers International Study Center on May 24, 1983 in Penang, Malaysia. The presentation was made by Dr. J. Rodney Lay, Managing Director of the Thailand Smelting and Refining Co., Ltd. (Thaisarco).

Thaisarco was started in 1965 by the Union Carbide Corporation to smelt Thai tin concentrates. Historically, tin concentrates produced in Thailand had been exported mainly to smelters in neighbouring Malaysia. Union Carbide had no great interest in the tin business as their major interest was in tantalum, present in Thai tin concentrates at a relatively high concentration. Also, Union Carbide had discovered, by brilliant interpretative geology, a very large offshore tin deposit in the Andaman Sea.

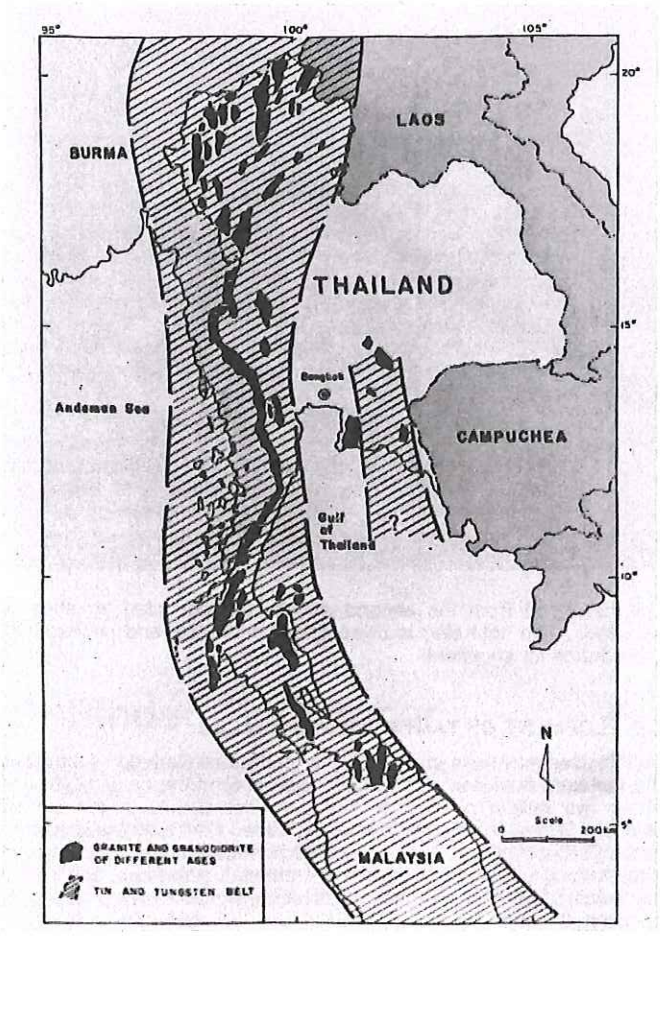
At the levels of tantalum in Thai ores, Union Carbide was confident that processing tantalum-containing slags would be an economically viable route to production of tantalum compounds and tantalum metal. They proved to be right. A series of process improvements, stimulated initially by Union Carbide's tantalum needs and, later, by Billiton to optimise tantalum slag production, led to a process that can produce slags containing up to 15 % Ta_2O_5 from feed material averaging around 0.9 % Ta_2O_5.

Due to the interest of Billiton to re-enter tin production after the loss of their Indonesian tin operations and a change in the Union Carbide corporate policy (1973), Billiton took up a 50 % interest in Thaisarco in 1970 and became the sole owner of Thaisarco and other Union Carbide tin interests in Thailand in 1975.

Thaisarco is, presently, the largest single source of tantalum in the world, producing about one-third of the free-world demand.

OCCURRENCE OF TANTALUM IN THAILAND

Tantalum is almost invariably found with tin. This is true not only in Thailand but in the whole of S.E. Asia and in Australia. Tantalum occurs as tantalite, (Fe, Mn) $(Ta, Nb)_2O_5$, and as struverite, (Ti, Fe, Ta, $Nb)_2O_4$, (tantalum modified rutile) in primary tin deposits, thus in pegmatites and in zones of contact mineralisation. It is also found with cassiterite (SnO_2) crystals as solid solutions and micronised exsolution textures in weathered products, eluvial, alluvial and placer deposits both offshore and onshore.



The tin belt of S.E. Asia extends some 3000 kms. from Burma via Thailand and West Malaysia to the so-called "tin-islands" of Indonesia, one of which was Billiton, which 123 years ago was the raison d'être for the Billiton Company from which the Billiton Group has grown, of which Thaisarco is a part.

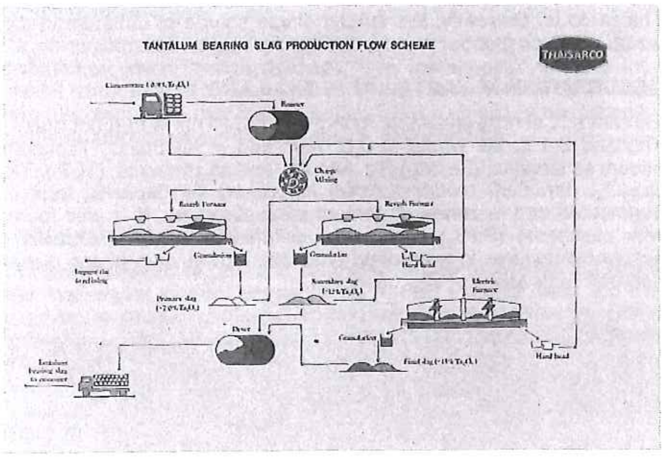
Within this tin belt there is a general younging of the host granites from east to west. The oldest granites in this part of the world occur in Malaysia and Eastern Thailand, the southern and western parts of peninsular Thailand. Although the style of mineralisation is important, it is nevertheless broadly true to say that the younger the granites, the higher the Ta content in the tin ores produced in Thailand. Northwards, the concentration of tantalite becomes lower and tungsten becomes the dominant by-product in tin mining.

Most of the free tantalite in the tin concentrates produced in Thailand is now electromagnetically separated at the ore-dressing stage by the miners or concentrate traders. Thus the concentrates produced by Thaisarco have been generally "cleaned out". Concentrates can still contain tantalum, however, when it is intergrown with the cassiterite crystal structure. It is inseparable by present-day ore dressing techniques and, therefore, can only be realised by smelting. The individual inclusions are very small, less than 0.015 mm. in diameter.

The average tantalum content of concentrates delivered to Thaisarco is now around 0.9 % Ta_2O_5 compared to around 1.2 % when Thaisarco started operating in 1965.

THE PRODUCTION PROCESS

The process used at Thaisarco is outlined in the following flowsheet :



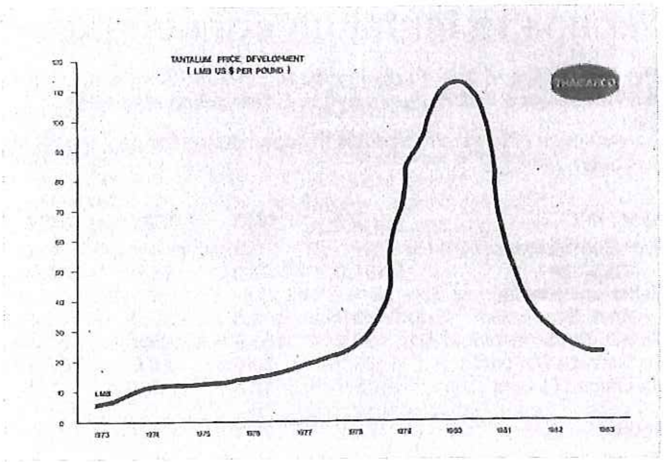
After receipt, sampling and assaying, concentrates are fed to a charge-mixer where reducing and fluxing agents are added. The mixed batch is then transferred to the reverberatory furnace. After smelting at 1350 °C, impure tin is tapped and transferred by overhead crane to the refinery or cast into pigs for subsequent refining. The first slag (formed during smelting) is similarly tapped and fed to a granulating pit, essentially a large bath of water. The effect of shock-cooling the red-hot slag produces a granular, easily handleable product. This primary slag contains about 7 % tantalum oxide and about 20 % tin.

The primary slag is fed to a second reverberatory furnace and resmelted to produce hardhead (a tin-iron alloy) and a secondary slag containing about 12 % tantalum oxide and about 4 % tin. After granulation, this slag is fed to an electric furnace for final upgrading to produce further hardhead and a final slag containing up to 15 % Ta_2O_5.

The hardhead from the second and third stage slag smelting is recycled. The final slag is dried after granulation and packed into steel drums for shipment.

DEVELOPMENT OF TANTALUM SLAG SALES

A factor that may have profoundly affected Union Carbide's attitude to the tantalum business was the disposal, around the early 1970's, of about two million pounds of Ta_2O_5 by the G.S.A. in the United States. Strong representations were made at the time by Thaisarco to the G.S.A. that such an action would be harmful, destabilising the market and leading later to a material shortage and price explosion. We were ignored. Subsequent price development supported that view.

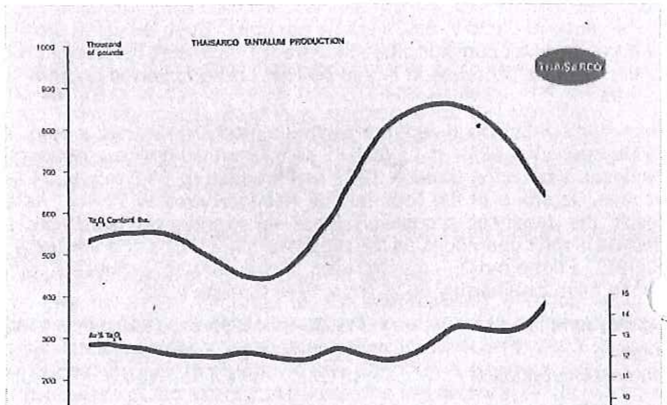


Billiton's main interest in acquiring Thaisarco was to support its tin business, previously based on its smelter in Arnhem, Holland. But Billiton became increasingly dependent on traded tin as the availability of high-grade concentrates to offshore smelters declined with the increase in domestic smelting in producer countries. Billiton has for decades supplied about 20 % of the free world's tin demand. Acquisition of Thaisarco was, therefore, a natural fit for the Billiton tin business at that time.

With respect to the tantalum containing tin slags, the withdrawal of Union Carbide from the upstream tantalum business necessitated the finding of other outlets in the early 1970's. It was decided to sell th tantalum slag through Billiton's mainstream marketing companie and, although the company names have changed over the years, that course is still followed. Contracts were obtained in 1973 with the major U.S. and German processors for all of the output from Thaisarco, although more recently all production has gone to the U.S.

Since the mid-seventies, the pricing base for sales from Thaisarco has been the London "Metal Bulletin" price for 30 % tantalite from which a processing cost differential was established to recognise the lower tantalum content of the Thaisarco slags.

The Thaisarco tantalum slag output, from 1971 through 1983, and the average Ta_2O_5 content is shown in the following chart :



THE FUTURE

As far as Thaisarco's future output is concerned, a few points are worth making :

1. Thaisarco's tantalum output, as most of the world's tantalum, is linked to and is determined by the tin concentrate production.
2. Thai tin production has entered, in our estimation, a period of decline related to quotas as a result of the depletion of known deposits (particularly by the small suction-boat operators) and the lack of investment in exploration.
3. Consequently, it is doubtful that Thaisarco tantalum output will ever again achieve the record levels of 1979 and 1980 unless a spectacular exploration and development effort leading to a large number of new mines is launched. This must be regarded as unlikely.

Nevertheless, for the foreseeable future, Thaisarco will remain a considerable producer of tantalum. Whether the slag is sold to existing overseas processors or it is sold to a domestic Thai processor depends, to a great extent, on the activities of the Thai Tantalum Industry Corporation in their new project.

Current status of the Thailand Tantalum Industry Corporation Project

The following paper was presented by Mr. Yeap Soon Sit, Managing Director of the Thailand Tantalum Industry Corporation, at the Nineteenth General Assembly of the Tantalum Producers International Study Center in Penang, Malaysia on May 24, 1983.

The Thailand Tantalum Industry Corporation (T.T.I.C.) project was first identified in 1978 by two mining concerns in Southern Thailand who later became sponsors of the present project. T.T.I.C. was incorporated in December 1979 by several major local mining groups. In June 1980, T.T.I.C. received approval from the Thailand Board of Investment for the implementation of the project in accordance with the privileges and conditions granted. The plants, to be located in Phuket, Southern Thailand, would exploit a business opportunity by providing in Asia a local capability to treat most types of tantalum containing raw materials, that is, tin slag (both low and high grade), struverite, columbite and tantalite to substitute for those bulky materials a higher value export of intermediate products for direct reprocessing into end products by the main processors.

It is unlikely, therefore, to be perceived as an immediate threat to the competitive end of the existing industry and will offer the established processors an assured supply of raw materials. In view of the increased uncertainty about mine sources of tantalite ores and the increasing reliance on Asian tin slags, T.T.I.C. would be providing tantalum production capacity needed by the industry in the medium to long term. Thus, the project is not expected to cause severe disruption to the existing industry structure.

Also, given the relatively low "production cost" of tin slags and T.T.I.C.'s favorable long-term processing cost effectiveness, T.T.I.C. will be a key source of economic and stable supply to the processors under fluctuating market conditions when supply from mine sources might be curtailed. Through its location advantages, close to 40 % of the world tantalum sources, and its processing technology capable of recovering tantalum from a wide quality range of raw material feed, the project is expected to have advantages in supplying intermediate products to processors in more distant locations.

PROCESSING DESIGN AND FACILITIES

Because of the different tantalum content contained in the various kinds of tantalum containing materials available in this area, two separate processing phases will be incorporated in the project design :

Step 1 — Low and medium grade slags will be first upgrated by means of an electric furnace process (smelter) which yields a so-called "synthetic concentrate" with an average of 25-30 % Ta_2O_5. The smelter is designed to process up to 7,000 m.t. of slag annually. The total annual tantalum output will depend on the tantalum content of the slag. This smelter will give, therefore, some valuable flexibility in adjusting the output in accordance with the market conditions.

Step 2 — The final production of tantalum pentoxide, potassium fluotantalate and the accompanying niobium pentoxide, as a co-product, in the chemical plant will start from tantalite, struverite, columbite, high-grade tin slag and the synthetic concentrate from the smelter. The process makes use of hydrofluoric acid digestion followed by liquid-liquid extraction with MIBK. The chemical plant is designed to treat up to 700,000 lb. Ta_2O_5 per annum contained in the various feed materials.

The technology and know-how for the two steps will be provided to T.T.I.C. by Hermann C. Starck Berlin of West Germany under an exclusive technology transfer agreement.

PROJECT TIMETABLE

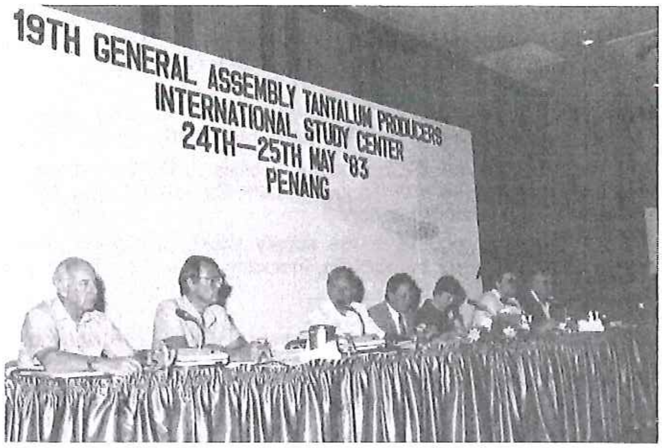
The project received the provisional approval of the investment committee of the International Finance Corporation, part of the World Bank, in January 1983 for the total financing requirements of about US $ 50 million. Assuming that the financing can be put together by the I.F.C. at a favorable rate and terms, construction work can begin in the coming dry season which begins in October 1983. The present schedule calls for the operation of the chemical plant to start in 1986 and, depending on the strength of the tantalum recovery, the smelter will start up in 1987 or 1988.

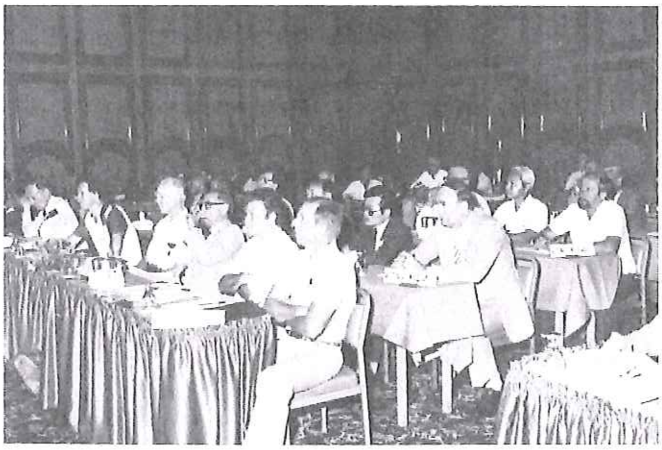
CONCLUSION

With the completion of the T.T.I.C. project, it is hoped that it will benefit the producers of tantalum raw materials in this region by offering them a competitive market for their materials and the assurance of a stable tantalum supply on a long-term basis to the other main processors.

Nineteenth General Assembly

The President and Executive Committee address the delegates attending the Nineteenth General Assembly.





The Guest of Honour, Datuk Mohamed bin Yeop Abdul Raof, President of the City Council of Penang, is welcomed to the Banquet by the heads of the host companies and the T.I.C. President.

Dr Binder, Treibacher

Dr Binder, plant manager, refractory carbides, of Treibacher Chemische Werke, died on July 10th.

He obtained his PhD under Professor Kieffer in Vienna, and held several positions in Treibach before taking over the carbides plant in 1972 and expanding it in the following years. Keeping also in the forefront of science, he published several articles on carbides and other hard materials.

Published Reports

It will be an objective of the "Bulletin" to publish, from time to time, a listing of recently published reports of interest to the readers. As the Editor has only limited access to current periodicals and trade journals, advice of newly published articles will be gratefully received from T.I.C. members and other readers of the "Bulletin". Please forward such information to the T.I.C. Secretary in Brussels.

The following articles have been recently published :

1. "Columbium, Mineral Commodity Profiles, 1983", by Larry D. Cunningham, Division of Ferrous Metals, Bureau of Mines, United States Department of Interior.
   — A complete resumé of the supply situation and the market requirements for columbium, including projections to the year 2000.

2. "Effect of Hydrogen on Near-threshold Crack Propagation in Niobium", S. Faiabi, A.L.W. Collins and K. Salama, "Metallurgical Transactions", Vol. 14A, April 1983, pp. 701-707.
   — The effects on near-threshold fatigue crack growth rate have been investigated in niobium at room temperature. Fatigue tests were performed on a hydrogen-free specimen as well as specimens containing hydrogen in solid solution and in the form of hydride. The results show that the threshold stress-intensity factor ΔK_{th} decreases with the addition of hydrogen and reaches a minimum at a hydrogen concentration approximately equal to the solubility limit of hydrogen in niobium. As the hydrogen concentration exceeds the solubility limit, ΔK_{th} increases with the increase in the amount of hydrogen dissolved in the specimen. Analysis of this behavior suggests that stress-induced hydride cannot be responsible for the embrittlement of niobium with hydrogen, and dislocation-hydrogen interaction plays an important role in the embrittlement process.

3. "Effect of Oxygen Level on Solid Tantalum Capacitors", M. Tierman and R.J. Millard, "IEEE Transactions", no. 0569-5503/83/0000-0157.
   — The increased surface area of high CV tantalum powders provides a greater area for surface oxidation during normal air exposure at room temperatures. The oxygen is driven into the interior of the tantalum structure during subsequent high temperature vacuum sintering which in turn provides a fresh tantalum surface for additional oxidation during the next air exposure. Approximately 500 p.p.m. of oxygen are added to the tantalum in each cycle. When oxygen solubility limits are exceeded, an oxide phase precipitates which can produce defects in the dielectric film subsequently formed by anodization. These defect sites cause leakage current problems which are evident at wet check, reverse polarity and load-life testing.
   Electrical evaluation and scanning electron microscopy show the importance of maintaining oxygen levels below critical values which appear to be in the range of 3200 to 4000 p.p.m.

4. "Araxa Niobium Mine", publ. in the "International Journal of Refractory & Hard Metals", Vol. 2, no. 1, March 1983, pp. 3-7.
   — The Araxa mine in Brazil is the western world's largest source of niobium and the article outlines its developments and the processes used to produce concentrates and ferro-niobium.

5. "Niobium : Use in Super-conducting Alloys Expands", publ. in the "International Journal of Refractory & Hard Metals", Vol. 2, no. 1, March 1983, p. 8.
   — A summary of the current status of niobium-base superconducting alloys.

6. "Kobe Steel Develops Niobium-base Superconductor Alloy", publ. in the "International Journal of Refractory & Hard Metals", Vol. 2, no. 1, March 1983, p. 10.
   — Describes the mechanical characteristics and processing of CRYOZIT, an innovative high-tensile superconductor produced by Kobe Steel in Japan.

Tantalum reports

The following reports on tantalum are currently available :

Title :	*Available from :*	*Price :*
Worldwide Tantalum Study : Assessment of Availability and Price, 1980-1985	T.I.C.	$ US 50
Explanation of Tantalum Market Behavior : 1980-1985	T.I.C.	$ US 50
Review of 1982 Tantalum Results and Updated Industry Outlook	T.I.C.	$ US 400
The Economics of Tantalum, Fourth Edition	Roskill Information Services	$ US 620
Untersuchungen über Angebot und Nachfrage mineralischer Rohstoffe : XVII Tantal (Translation into English is being prepared : apply to T.I.C.)	Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover	
Final report of "The Panel on Tantalum and Columbium Supply and Demand Outlook" - Publication NMAB-391	National Technical Information Service, Springfield, VA 22151, U.S.A.	Apply to NMAB

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