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TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

Dear Members and Friends,

As I embark on my tenure as President of the T.I.C., I would like to take this opportunity to give warm thanks again to my predecessor Mr Yeap Soon Sit. His efforts throughout the year culminated in a very successful and enjoyable General Assembly held in Xian from October 5th to the 8th 1997.

Our past President in co-ordination with our Secretary General, Mrs Judy Wickens, and Technical Adviser, Dr George Korinek, ensured an interesting and well attended programme of events and technical papers. On behalf of all the members of the T.I.C., I would like to express our congratulations to them all for a job well done.

For many of those (including myself) attending the Thirty-eighth General Assembly in China, it was a first visit to a fascinating and spectacular country. We are very grateful to our hosts Ningxia Non-ferrous Metals Smelter and the Non-ferrous Metals Society of China for generously helping to contribute to our education, and to the success of the meeting itself. The plant tour to Shizuishan City is an enduring memory.

Next year's General Assembly will be held in the historic city of Prague, the 'hundred-towered' or 'golden' city on the Vltava, the capital of the Czech Republic. AVX has agreed to act as our host for the meeting and has arranged the venue to be the Inter-Continental Hotel for October 11th to the 13th 1998. I am looking forward to seeing you all there.

Finally, may I take this opportunity to wish you all a happy, healthy and prosperous New Year.

Bill Millman
President

SUMMARY

XIAN MEETING

The meeting of the Tantalum-Niobium International Study Center held in China from October 5th to 8th, which included the Thirty-eighth General Assembly, went well. Hosts Ningxia Non-ferrous Metals Smelter and China Non-ferrous Metals Society helped extensively with the technical programme, local arrangements and administration.

The large party of delegates who took the charter flight to Yinchuan and then continued by road to Shizuishan City to visit the plant of Ningxia Non-ferrous Metals enjoyed great hospitality and a most interesting day. Many delegates took advantage of the opportunity to see the Terra Cotta Army created over two thousand years ago and entombed to protect the burial place of the Emperor who unified China.

The General Assembly carried forth the business of the association, approving a satisfactory financial situation, and electing six new members (see last page). Mr Yeap Soon Sit, S.A. Minerals, completed his term of office with this successful meeting, and Mr William Millman of AVX was elected President for the next year, which will include the General Assembly in Prague and a tour of the Czech Republic plant of AVX manufacturing capacitors. Statistics collection was reviewed and a quarterly collection of data on receipts of powder and wire by capacitor plants was initiated.

A splendid banquet was hosted by Ningxia Non-ferrous Metals Smelter at the Tang Dynasty theatre restaurant with a performance of music and dance which greatly impressed the conference delegates. Guided sightseeing tours for those accompanying the delegates, and a welcome reception completed the events.

Papers from the technical programme will be published in the next issues of this Bulletin.

1 Group for the plant tour, at the gate of NNMS

2 Tour of the powder plant

3 Group at the Wet Processing plant

4 Participants enjoying music and dance at the Tang Dynasty theatre restaurant

5 Mr He Ji Lin, Managing Director, Chief Engineer, Professor Senior Engineer of Ningxia Non-ferrous Metals Smelter and North Rare Metal Materials Research Institute, with Mrs Judy Wickens and Mr Yeap Soon Sit at the Tang Dynasty Banquet

6 Mr Ma Fu Kang, Secretary General of the Non-ferrous Metals Society of China, at the opening of the technical session

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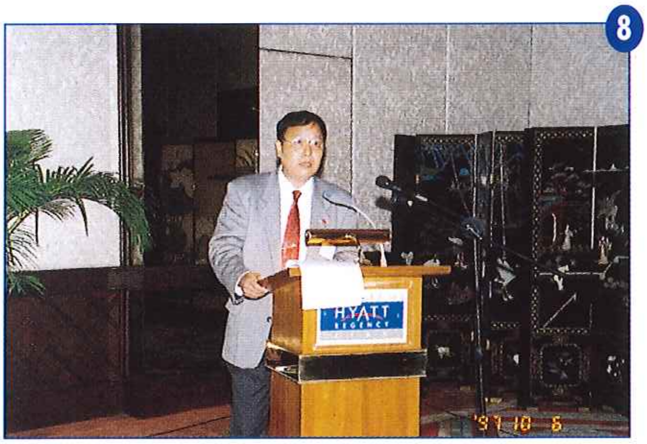

7 Mr Zeng Fang Ping, Deputy Chief Engineer, Professor Senior Engineer of NNMS

8 Mr Zhou Ju Qiu, President and Senior Engineer of Zhuzhou Cemented Carbide Works

9 Mr Susumu Wada, Hitachi AIC

10 Mr Art Yarzumbeck, General Manager, Shenzhen GKI Electronics

11 Dr Yin Wei Hong, Vice President of Northwest Institute for Non-ferrous Metals Research

12 Dr George J. Korinek, Technical Adviser, T.I.C.

13 Technical session at the Hyatt Regency Hotel

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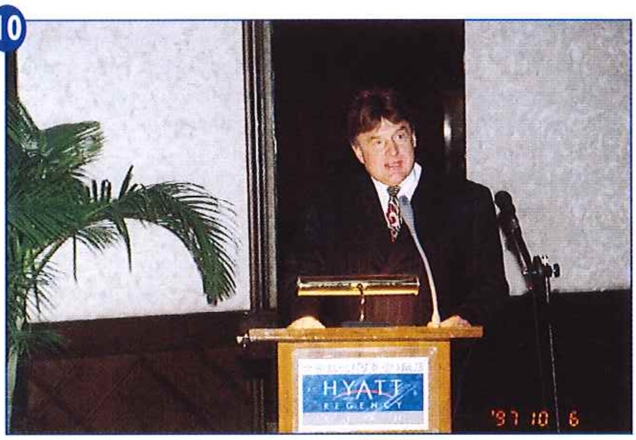

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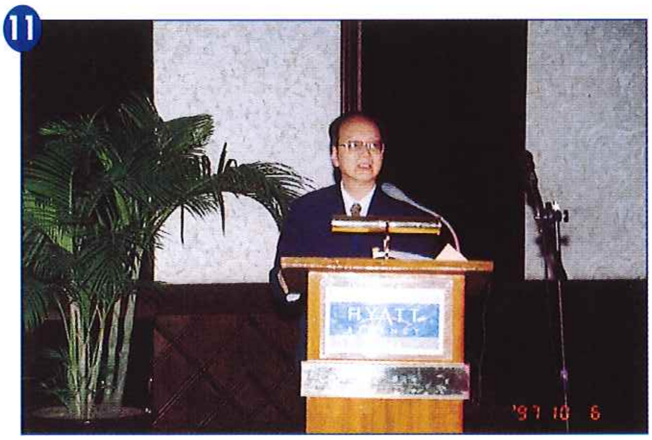

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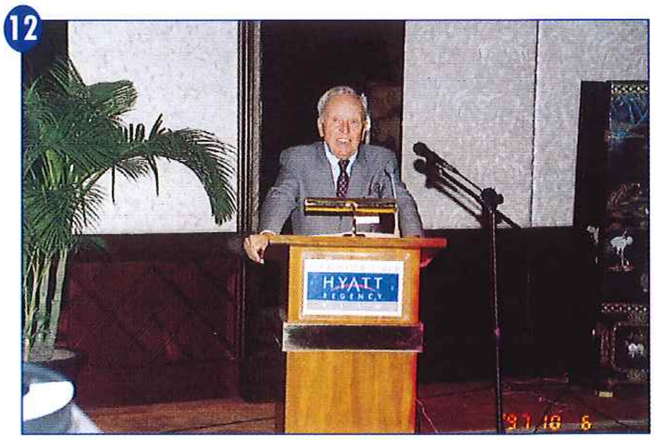

DEVELOPMENTS IN TANTALUM AND NIOBIUM DURNG THE LAST YEAR

by George J. Korinek, Technical Adviser to the T.I.C. This paper was presented at the meeting in Xian, China, in October 1997

During the last meeting in Greenville, I mentioned several major structural developments in our industry which took place between our Symposium in Goslar in the fall of 1995 and fall of 1996. I would like to report shortly on the progress of these developments.

1. Transfer of the carbide powder business from LSM to Treibach. This transfer was fully completed and LSM is no longer active in the carbide area.
2. Cabot, in co-operation with Madal S.A.R.L. and Lydenburg Exploration, planned a feasibility study on the Morrua tantalum property in Mozambique. This study was completed in August 1997 with positive reults and the project appears viable. Implementation would add 400 000 lb Ta_2O_5 to the production of tantalum raw materials and the current plan is to start up the mine by the year 2000.
3. The acquisition by H.C. Starck of the Thai Tantalum plant in Map Ta Phut was completed and the facility has been totally integrated with HCST's production facilities in Goslar, Newton and Japan. The facility operates under the name of H.C. Starck (Thailand).
4. The Gwalia take-over of the Wodgina tantalum mine has also been fully completed and about the production I will report later in this presentation.
5. The partnership between Vishay Intertechnology, the Eisenberg Group of companies and CNNC is being finalized and three separate joint ventures will result:
   - with Yichun Tantalum and Niobium Mine, to expand and modernize the mine
   - with Ningxia Non-ferrous Metals Smelter, to expand the tantalum refinery
   - with CNN Engineering Ltd., to build a new capacitor plant.

   Vishay will have the controlling interest in the mining venture and the capacitor plant and CNNC will have a controlling interest in the tantalum refinery.
6. There is nothing new to report about the offer of Vishay to take over Kemet, which was rejected.
7. Metallurg's investment in Solikamsk Magnesium Works was finalized and both companies co-operate closely in the tantalum and niobium oxide area.

In summary, last year was a year of consolidation of the different restructurings which had been announced earlier and to my knowledge there was not any new major transaction taking place in the last twelve months.

Even though it is not really a restructuring, I would like to mention at this point that less than one month ago Metallurg's extraction facility in Brazil experienced a serious fire in the liquid-liquid part of the plant with resulting serious damage to both the equipment and the building, and this facility will be out of operation at least for the next six months.

NIOBIUM DEMAND

1996 was a good year for niobium. Figure 1 shows the total niobium shipments and shipments of ferro-niobium (all in million lb of Nb). According to the T.I.C. statistics, that would indicate a slight decrease in shipments of total Nb and Nb in FeNb compared to 1995. Actually this decrease is caused by an internal decrease of inventories of the largest producer CBMM and actual consumption in 1996 was slightly ahead of 1995. This is mainly in the area of standard FeNb but because of its importance affects to the same degree the total niobium shipments.

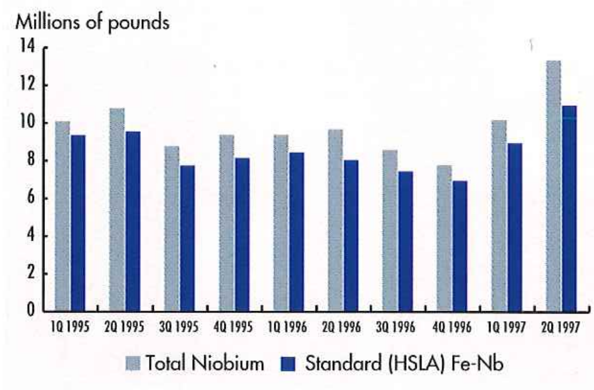

Figure 1: Niobium shipments: total niobium and standard (HSLA) Fe-Nb [based on T.I.C. statistics]

Whereas the quarterly figures for 1996 are the actual reported figures of T.I.C., the breakdown of the first half year figure for 1997 into quarters is my estimate.

CBMM remains by far the single largest source of niobium. During 1996 it shipped out 16 000 MT of FeNb, over 90% of which was exported. The main markets are Europe, Japan and the U.S., which together amount to 85% of all exports.

Catalao, a member of the Anglo Group, shipped about 3600 tons of FeNb in 1996, virtually unchanged from 1995.

The Niobec Mine of Cambior and the Teck Group in Quebec, Canada, is the largest North American primary producer of niobium. In 1996 the production was 3322 MT of Nb_2O_5 contained in concentrate. All the concentrate is converted to FeNb internally by aluminothermic process.

The Lueshe Mine of Metallurg Group in Zaire remains closed.

CBMM recently announced the increase of its ferro-niobium capacity from the current 23 000 tpy to 30 000 tpy by the end of 1997. The actual production will be increased only as the market requires. The aim of the capacity increase is to keep the pricing stable and to guarantee sufficient supply in the future. CBMM will continue with its production level of 50 tpy of niobium metal and 2000 tpy of niobium pentoxide. The company also plans to start producing 150 tons of high purity (99.9%+) Nb_2O_5 in the first half of 1998.

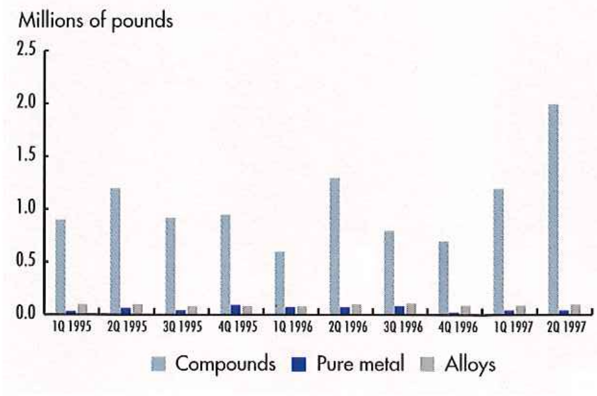

Figure 2: Niobium shipments: compounds, pure metal and alloys [based on T.I.C. statistics]

The category of compounds and alloy additives which contains mainly vacuum grade ferro-niobium and nickel-niobium is the largest useage of niobium and continued very strongly. And we can see from Figure 2 that there is a large increase in shipments in this category for the first and second quarter of 1997 and reflects the strong market for superalloys for jet engines and stationary turbines. I will touch upon this subject also in connection with tantalum.

The metal and alloy sector is rather stagnating at about 0.5 million lb Nb per year. This sector should be helped by the LHC (Large Hadron Collider) project at CERN facility outside Geneva which could use close to 400 tons of niobium during the next five years.

In summary, the outlook for niobium remains positive.

TANTALUM

I will touch shortly on raw materials and then discuss the demand.

Gwalia remains by far the largest single primary producer of tantalum raw materials. The production during the fiscal year ending June 30th 1997 increased to over 800 000 lb of Ta_2O_5, the budgeted production for the current fiscal year is 740 000 lb Ta_2O_5 in concentrate from Greenbushes, Wodgina and Bynoe Mines and 100 000 lb Ta_2O_5 in glass. Production at Wodgina is to increase slightly over the next two years to a level of 250 000 to 300 000 lb of Ta_2O_5 and Gwalia is aiming to supply about 1 000 000 lb of Ta_2O_5 by the year 2000.

The Tantalum Mining Corporation of Canada produced about 140 000 lb Ta_2O_5 in concentrate in 1996 from primary mining activities and from processing of stockpile tailings.

The political and economic situation in some of the African countries seems to be improving and that should result in increasing production of tantalum concentrate from this part of the world. Steps toward privatization of the tantalum mining in Ethiopia are under way, about the project in Mozambique we reported earlier and also in Zaire and Rwanda there seem to be steps taken to increase local production. In addition there are well over 10 000 000 lb of Ta_2O_5 above ground mainly in the form of low grade slags from past productions, DLA tantalite stockpile, and residues from past operations at the converters' sites. There is still an unknown quantity of low grade slags, in the form of land fill, in different locations in South East Asia.

In addition to the present tantalite production, additional potential reserves have been indicated in Brazil, Bolivia and Venezuela.

TANTALUM CONSUMPTION

Figure 3 shows the breakdown of the shipments of tantalum products by processors for 1996. About half of the mill products are being shipped to the capacitor industry in the form of wire and furnace hardware and together with the powder shipments add to over 60% of the total. Figure 4 shows shipments by quarter for the main product lines for the last eight quarters. Because of the changes in the statistics collections we have available only semi-annual data starting January 1st 1997, but I have tried to estimate this consumption by quarter to preserve some continuity. The total tantalum consumption peaked in the first quarter of 1996 and declined during the rest of the year. A similar development can be seen for the tantalum powder consumption. As we mentioned last year, this decrease resulted from a weaker temporary demand for capacitors in personal computers and some telecommunications equipment at that time and mainly by the liquidation of capacitor inventories which accumulated during the latter part of 1995. During our last meeting in Greenville, we predicted that this correction should be completed by the end of 1996 and the growth should resume in the first quarter of 1997, the data indicate that this also actually happened. There was an improvement in the first quarter and this accelerated during the second quarter of 1997. A similar development occurred in the other product lines (see Figure 5), with the exception of alloy additives and scrap which did not experience any decrease in the latter part of 1996 and showed a continuous growth. This development is due to the strength of the superalloy sector, mainly of the single crystal alloys for jet engines. Figure 6 gives the composition of these alloys, just to refresh your memories, and they are used mainly in the hot part of the engine.

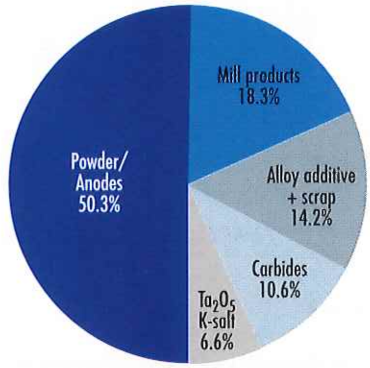

Figure 3: Shipments of tantalum products by processors, 1996 [T.I.C. statistics]

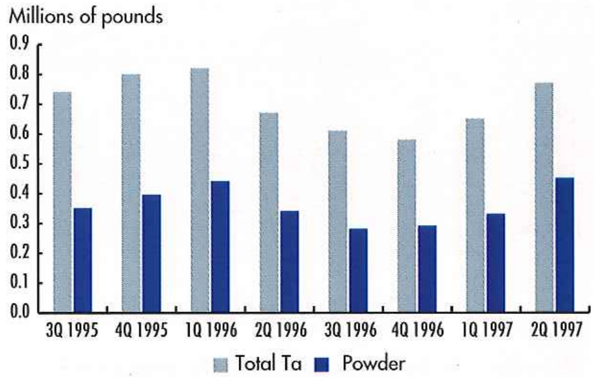

Figure 4: Tantalum shipments: total tantalum and tantalum powder [T.I.C. statistics]

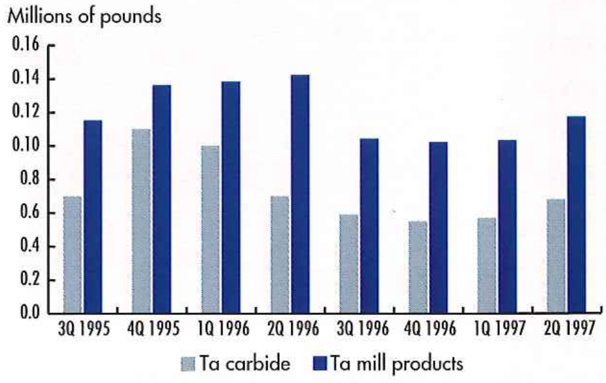

Figure 5: Tantalum shipments: carbide and mill products [T.I.C. statistics]

Alloy	Cr	Co	Mo	W	Ta	Al	Ti	Re	Ni
	FIRST GENERATION								
PWA 1480	10.0	5.0		4.0	12.0	5.0	1.5		BAL.
RENE N4	9.0	8.0	2.0	6.0	4.0	3.7	4.2		BAL.
SRR 99	8.0	5.0		10.0	3.0	5.5	2.2		BAL.
RR 2000	10.0	15.0	3.0			5.5	4.0		BAL.
AM 1	8.0	6.0	2.0	6.0	9.0	5.2	1.2		BAL.
AM 3	8.0	6.0	2.0	5.0	4.0	6.0	2.0		BAL.
CMSX-2	8.0	5.0	0.6	8.0	6.0	5.6	1.0		BAL.
CMSX-6	10.0	5.0	3.0		2.0	4.8	4.7		BAL.
AF 56	12.0	8.0	2.0	4.0	5.0	3.4	4.2		BAL.
	SECOND GENERATION								
CMSX-4	6.5	9.0	0.6	6.0	6.5	5.6	1.0	3.0	BAL.
PWA 1484	5.0	10.0	2.0	6.0	9.0	5.6		3.0	BAL.
SC 180	5.0	10.0	2.0	5.0	8.5	5.2	1.0	3.0	BAL.
MC 2	8.0	5.0	2.0	8.0	6.0	5.0	1.5		BAL.
RENE N5	7.0	8.0	2.0	5.0	7.0	6.2		3.0	BAL.
	THIRD GENERATION								
CMSX-10	1.8-4.0	1.5-9.0	0.25-2.0	3.5-7.5	7.0-10.0	5.0-7.0	0.1-1.2	5.0-7.0	BAL.
RENE N6	4.25-6.0	10.0-15.0	0.5-2.0	5.0-6.5	7.0-9.25	5.0-6.25		5.1-5.6	BAL.

Figure 6: Major alloying elements of single crystal alloys [G. Erickson, Journal of Metals, April 1995, p. 36]

What is the outlook?

At present the demand is very strong, mainly for the capacitor and superalloy industries. Figure 7 shows the tantalum capacitor production for 1994 to 1997. Basically we are on the growth curve as predicted by Dave Maguire at the Symposium in Goslar in 1995 with an estimate of 25 billion capacitors for the year 2000.

	Shipment (billions of units)	**U.S. $** (billions)
1994	10.4	1.3
1995	13.8	1.8
1996	12.8	1.7
1997*	15.8	2.0
(* forecast)		

Figure 7: Tantalum capacitor shipments worldwide

The outlook for the superalloy industry for jet engines is excellent. Figure 8 shows the official 20 year forecast of Boeing Company for airplanes for 1995 to 2015.

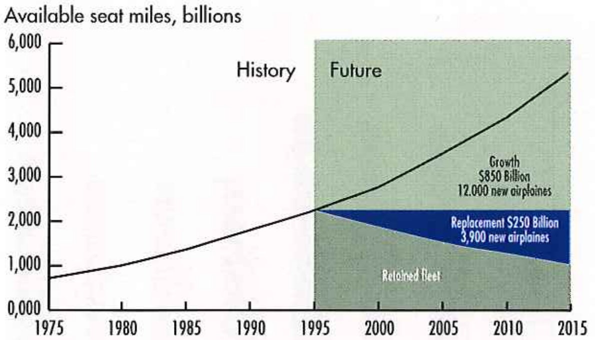

Figure 8: Total market for new airplanes, $1.1 trillion (available seat miles in billions) [Source: The Boeing Company]

Tantalum carbide will grow more modestly and be dependent on metal cutting activities.

In summary, in 1997 we will recover the 7% loss in consumption from 1995 to 1996, we will overtake the record year 1995 with its consumption of 2.86 million lb Ta and 1997 should be the first year in tantalum history with shipments of over 3 million lb.

CHINA'S TANTALUM RESOURCES, RAW MATERIAL PRODUCTION AND SUPPLY

by Wu Rui Rong, Qian Guo Wen, Nie Ming Liang, Zhang Xu Qing, Zeng Fang Ping, presented at the Thirty-eighth General Assembly meeting of the T.I.C., October 1997

ABSTRACT

This paper reports on the situation of China's tantalum raw materials. Tantalum reserves, deposit characteristics, mining methods, mineral beneficiation processes and quality standards of concentrates are briefly described. The market demand/supply and its general trend is also discussed.

INTRODUCTION

The construction of tantalum/niobium mines in China began in the 1950's. The earliest mines put into operation were Limu Tin Mines, Keketuohai Mine, Aletai Mine and Taimei Mine. Yichun Tantalum and Niobium Mine began its construction in the early 1970's, and it turned into the most important tantalum mine in China after finishing the first phase of its construction. In the past 40 years of construction and renovation, China built up more than ten tantalum and niobium mines. The ten major ones brought the total capacity for tantalum concentrates up to 90-100 tons of Ta_2O_5 per year, and niobium concentrates to 130-140 tons of Nb_2O_5 per year. Depending on these mines for raw material supply, China balanced demand and supply in the domestic market for decades, but the balance was upset in 1994 by sharply increasing demand from the processors both in China and outside China. Now China began to import tantalum raw material quite actively. Will China become a country of solely importing tantalum raw material?

TANTALUM RESOURCES

The total tantalum reserve in China, as reported in 1988, was measured to be approximately 60 700 tons Ta_2O_5. The industrial reserve was reported in 1992 as about 39 800 tons Ta_2O_5 and about 116 000 tons Nb_2O_5.

A number of tantalum/niobium deposits are recognized. The deposits are distributed in about 20 provinces, such as Jiangxi, Xinjiang, Hunan, Guangxi, Guangdong, Fujian. Jiangxi province has many more tantalum deposits than any other province, about 20 deposits have so far been proven in this province. These deposits make Jiangxi a tantalum reserve of 22 700 tons of Ta_2O_5, which accounts for 37.4% of China's total reserve. Among these, Yichun Tantalum and Niobium Mine holds the largest reserve in China. Its industrial reserve is 18 000 tons Ta_2O_5 and 14 900 tons Nb_2O_5.

Province (Area)	Deposit	Reserves
Heilongjian	1	15
Liaoning	1	31
Shandong	1	102
Henan	2	255
Hubei	1	1037
Fujian	2	1723
Jiangxi	15	22668
Hunan	5	7353.9
Guangdong	8	17706
Guangxi	3	2815
Sichuan	7	4443
Xinjiang	2	1046.2
Others		1489.5
Total		60684.6

Table 1: Tantalum reserves in China, in tons Ta_2O_5, as reported in 1988

As for niobium resources, in addition to those accompanying tantalum, there are several orebodies demonstrated to be mainly niobium principally without tantalum accompanying. Baiyunebo Iron Mine of Baotou, Inner Mongolia, is the largest niobium resource in China, it accounts for more than forty per cent of China's total niobium reserve.

Tantalum/niobium deposits found in China are mainly in three categories: granitic pegmatite type, granite type and hydrothermal type.

The granitic pegmatite tantalum/niobium deposits are the most common type and are widely spread in many provinces such as Xinjiang, Fujian, Jiangxi, Hunan, Guangdong, Guangxi and Sichuan and so on. Keketuohai Tantalum/Niobium Mine of Xinjiang is typical in this category. In Keketuohai deposit, the minerals are not homogeneously dispersed in the ore and the particles are very coarse in size. Keketuohai contains a great deal of spodumene.

The granite type of tantalum niobium deposits are found to be clustered in the area of Jiangxi, Guangxi and Guangdong, hardly ever to be seen in other areas. Yichun Tantalum and Niobium Mine is a large albite-lepidolite-granite deposit containing a number of rare metals such as tantalum, niobium, lithium, rubidium, cesium, etc. Its ore body is located at the top of a granite laccolith occurring as a hill, with most portions outcropped. The main orebody is of three natural types: surface eluvial deposit on the surficial hill flank, weathered and partly weathered deposit extending to the deeper position, and the primary (hard rock) deposit in the depth. In the ore body, the albite content decreases with the depth. The mica content displays a similar variation, and its species vary in such a series: lepidolite at the upper position, muscovite in the middle and biotite in the depth. At the same time, these features also vary regularly along the depth: the tantalum and niobium contents decrease and become more scattered, the association of the minerals is much more complicated, the hardness of the rocks increases.

The hydrothermal type of tantalum deposits is not common in China, and few are of economic significance in tantalum grade or tantalum reserve. Important deposits are only found in Inner Mongolia and Hunan province. Baiyunebo Iron Mine in Inner Mongolia is a typical hydrothermal metasomatic deposit. It is abundant in niobium and rare earths, but contains no tantalum. The mineral composition of the ore is very complicated, thus making the separation and beneficiation very difficult.

Typical examples of these types of deposits are listed in Table 2.

Type	Sub-type	Main Industrial Minerals	Main gangue minerals	Typical mines
Granitic-Pegmatite	Granitic-pegmatite	Niobite-tantalite	Muscovite	Keketuohai Mine
		Manganoniobate	Feldspar	Altai Mine
		Spodumene	Quartz	Nanping Mine
		Beryl		
Granite	Alkali-granite	Microlite	Feldspar	Hengfeng Mine
		Niobite-tantalite	Quartz	
		Cassiterite	Lepidomelane	
		Wolframite	Topaz	
	Microcline-granite	Fergusonite	Feldspar	Guposhan Mine
		Euxenite	Quartz	
		Polycrase	Hafnon-zircon	
		Niobite		
	Albite-granite	Mangano-niobtantalite	Feldspar	Yichun Ta-Nb Mine
			Quartz	
		Microlite	Lepidolite	
		Cassiterite	Bowleyite	Limu Tin Mine
		Tantalorutile	Topaz	
		Wolframite		
		Zircon		
Hydrothermo-Metasomatic	Precipitate hydrothermal metasomatic	Ilmenite	Feldspar	Baiyunebo Mine
		Magnetite	Quartz	
		Hematite		
		Niobite		
		Aeschynite		
		Bunsite		

Table 2: Types of tantalum/niobium deposits in China

CONCENTRATE PRODUCTION

The processes for producing tantalum concentrates are more or less different in different mines, it is not easy to describe all the details. Here, we are taking Yichun as an example, trying to describe briefly some of the general features.

Mining

Most of the tantalum mines in China are open-cut mines. Yichun Mine is a typical example. Its orebody is on a hill and most portions have outcropped, the stripping ratio is small, so open cast is naturally the ideal method here.

In Yichun, the mining operation starts from the top of the hill, developing downward stepwise against the elevation. Workings (normally two or three) are set on the levels at every ten-metre interval of elevation. When rock-drills are drilling holes at the top level to prepare for a blasting operation, a scraper is loading ore into the mine-trucks at the second level 10 metres below the first one. At a distance from there, another scraper is working with trucks in a mining field at the third level, 10 metres below the second one, and some drilling machines are working on the second level.

The ore body in Yichun Mine is of a disintegrated block structure. Such an unfavorable geology condition makes the blasting operation poor in efficiency. A number of big blocks were always produced in blasting. The operations of drilling holes in these blocks individually and blowing them up separately were very troublesome and had had a severe negative influence on productivity. In years of close co-operation with research and development institutes, Yichun Mine worked out a series of technological measures. With those measures carefully carried out in the mining practice, Yichun successfully reduced the big-block-rate in the blasting operation.

After blasting, the ore is transferred to the mineral dressing plant using a combined conveyance system. Such a system is composed of three sections: trucks, conveyance shaft and trams. After being loaded by scraper at the mine workings, the mine-trucks run along several miles of spiral mountain road, and then dump their load into the shaft at its top inlet, which is located at an elevation hundreds of metres below the workings. The crude ore slides vertically down hundreds of metres of elevation in the shaft; at the bottom outlet of the shaft, located in a tunnel, the trams are loaded with the crude ore. Then they are transferred by railway to the mineral dressing plant at the midpoint of the mountain, and the crude ore is unloaded into storage. (The flow chart is shown in Fig. 1.)

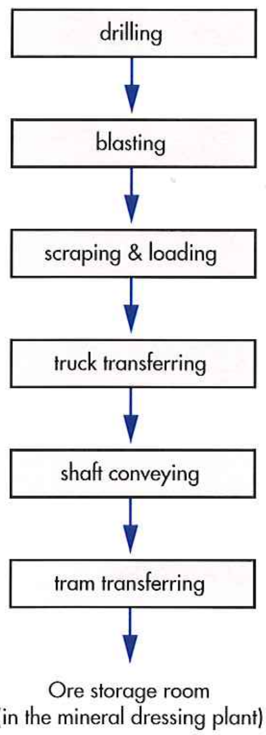

Figure 1: Mining operation and ore transfer in Yichun

Ore Crushing and Grinding

Prior to the separation of the valuable minerals from the waste, ore crushing is an essential step in all the tantalum mines in China; Keketuohai Mine and Limu Tin Mine use two-step open circuit crushing operations. But Limu adds two screens (bar screen) prior to the crusher for pre-screening. In Yichun, the blocks in the crude ore fed in are very large in size, while the ore sands suitable for separating and concentrating are required to be fine. So a three-step open-circuit route is selected in Yichun for ore crushing/washing. Three crushers - a jaw crusher, a standard cone crusher and a short head cone crusher - are working in series. A vibrating feed screen (ZGSJ screen) is positioned prior to the jaw crusher, the other two screens and one single-axis screw classifier are following in series. (See Fig. 2.)

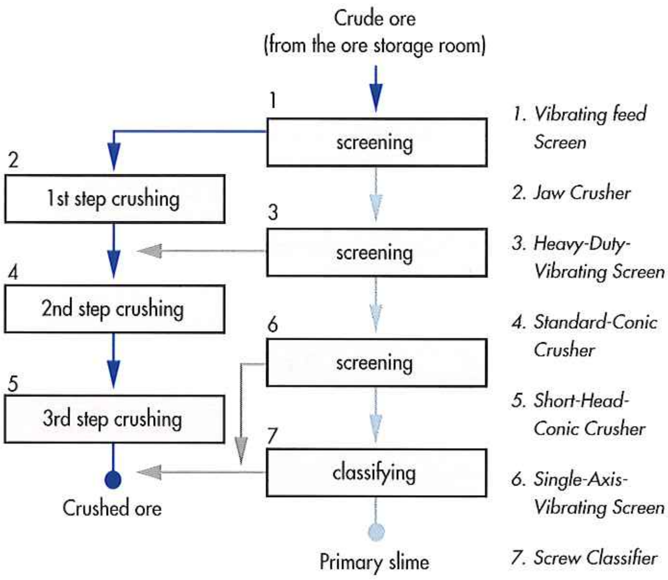

Figure 2: Ore crushing process in Yichun

The valuable minerals in the ore are still not well liberated after crushing, so further grinding is needed. Tantalum/niobium ores are friable, the particles of the valuable minerals are usually in a large range of sizes, and their distribution in the orebody is normally not even. Care should be taken to minimize over-grinding, so mines usually use stage grinding and stage concentrating, so that the valuable portions can be recovered once they are set free from the tailings.

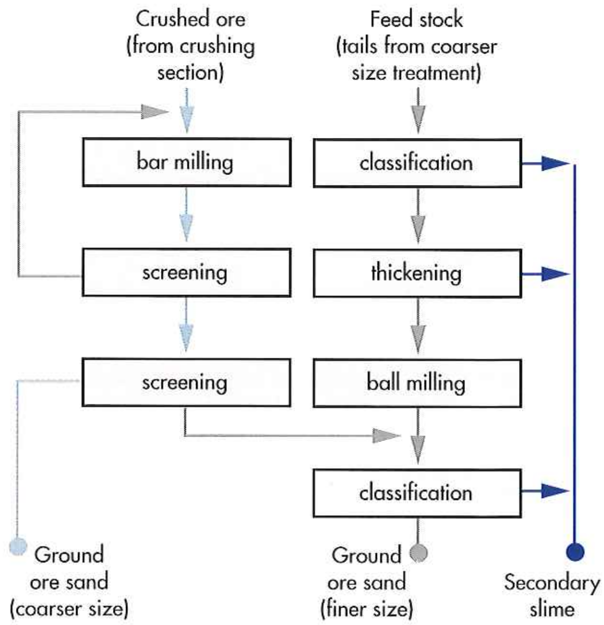

Figure 3: Ore grinding process in Yichun

In Yichun, the first step grinding is a closed circuit made up of a bar mill and a linear oscillating sleeve. (Some others use sieve bend.) The second step grinding is an open circuit with a grate discharge ball mill as the main equipment. (See Fig. 3.)

The Keketuohai Mine uses an open pit method.

The Shuiximiao Mine in Guangxi and the Aletai Mine in Xinjiang are underground operations; they are small in scale.

Gravity Concentration

Because the specific gravity of tantalum minerals is much larger than that of the gangue minerals (more than twice as high), gravity concentration is a predominant process for beneficiating the tantalum minerals, and equipment such as spiral chutes, rotary spiral chutes and tables is widely used in tantalum/niobium dressing plants.

The ore sands of different grinding routes differ in mineral composition and physical properties, so the process and equipment used to treat different ore sands are designed differently. In Yichun, the ore sand of the bar mill route goes to the coarser size treatment section (Fig. 4), and the sand of the ball mill route goes to the finer size treatment section (Fig. 5). It is believed that such a process is able to minimize over-grinding and achieve higher concentration efficiency.

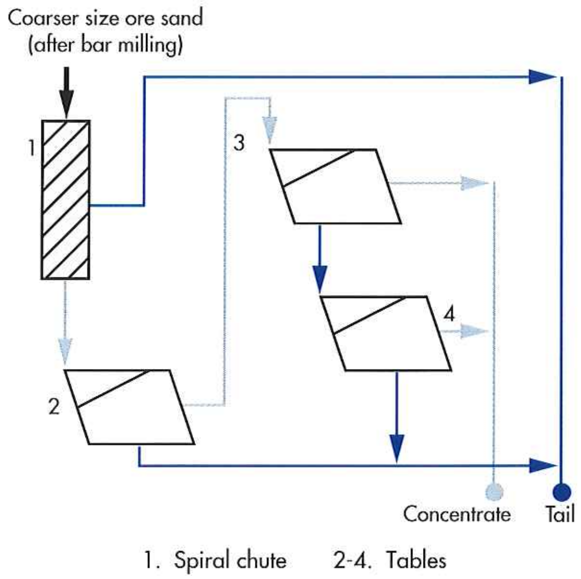

Figure 4: Concentration flow chart for coarser size ore sand

Similar principles can be used with the slimes. Slimes collected from different process routes are different in particle size and mineral composition, so different slimes should be treated in different facilities and with different methods. In Yichun Mine, the primary slime which is washed out from the crude ore by a four-stage washing operation (see Fig. 2), is treated in a process route for concentrating primary slime only. After stripping off the inclusions, overflowing the fines and adjusting the thickness, the slime is fed into rotary spiral chutes and a series of tables to be concentrated into a high grade tantalum concentrate (Fig. 6). While the secondary slime, which is collected in the grinding section through several steps of classification (see Fig. 3), is treated in a process for secondary slime concentration only. After inclusion cleaning, fine stripping and thickness adjustment, it goes through a rotary spiral and tables to be concentrated (Fig. 7). For secondary slimes, Yichun Mine also tried a gravity-flotation-gravity process experimentally, and it showed good results.

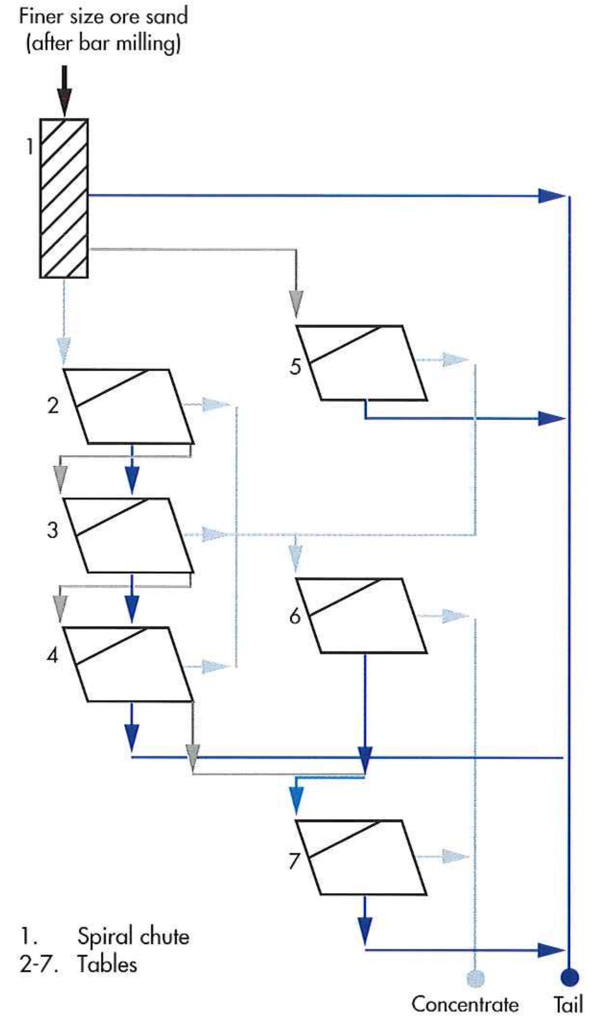

Figure 5: Concentration flow chart for finer size ore sand

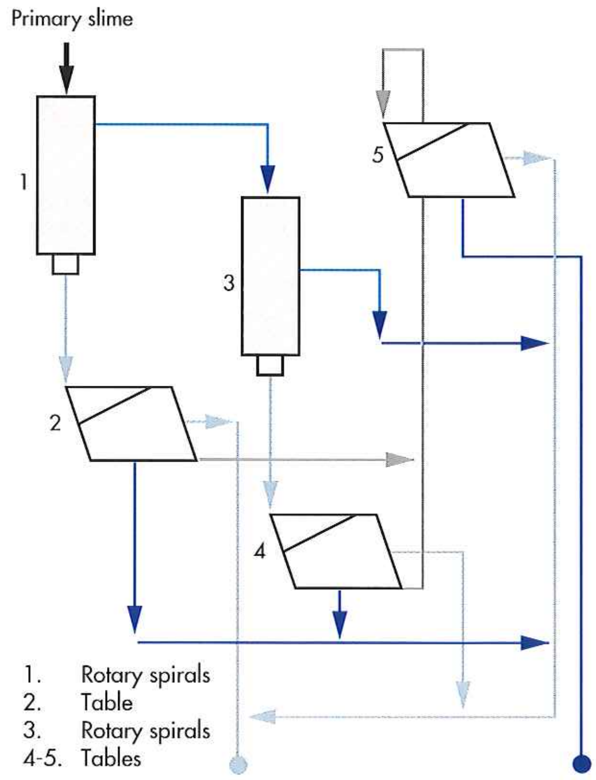

Figure 6: Concentration flow chart for primary slime

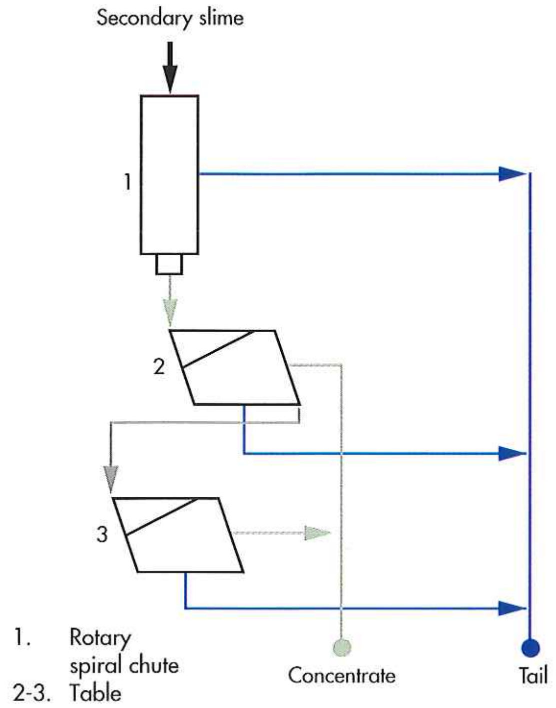

Figure 7. Concentration flow chart for secondary slime

Unlike Yichun where all the final concentrations are carried out on shaking tables, the other mines use these three different process routes in their final concentration operations: gravity-magnetic-gravity; gravity-magnetic-electric and gravity-magnetic-hydrometallurgical method.

Because the tantalum ore at various mines differs in properties and performances, the processes used to treat the ore vary also. Hence the production data in these different ore dressing plants have some differences. We collected some data, these are listed in Table 3.

Ore dressing plant	Concentration indexes (%)				
	γ	α	β	θ	ε
Yichun	0.361	0.0314	43.99	0.0155	50.59
Paitan	0.0062	0.0083	55.80	0.0048	41.85
Keketuohai	0.0325	0.025	50.00	0.00875	65.00

Note:

γ The productivity of concentrates, i.e. the rate (percentage) of the amount of concentrate produced to the amount of ore treated.

α The grade of crude ore, i.e. the percentage content of $(TaNb)_2O_5$ in the crude ore treated.

β The grade of concentrate, i.e. the percentage content of $(TaNb)_2O_5$ in the concentrate produced.

θ The grade of tails, i.e. the percentage content of $(TaNb)_2O_5$ in the tails.

ε The yield of the plant, i.e. the percentage rate of the amount of $(TaNb)_2O_5$ in the concentrates produced to the amount of $(TaNb)_2O_5$ in the ore treated.

ε (theoretical) = $\beta(\alpha-\theta)/\alpha(\beta-\theta) \times 100\%$

Table 3: Beneficiation data, tantalum ore dressing plants

Product Quality

Although the conditions are different in various tantalum mines, all the tantalum raw material producers in China are using the same product standard - the national trade standards within the tantalum industry (Table 4). Their products all meet the requirements of the domestic market and international market.

Grade	Chemical composition %				
	$Ta_2O_5+Nb_2O_5$	Ta_2O_5	Impurity no more than		
			TiO_2	SiO_2	WO_3
A-1	60	40	5	7	3
A-2	55	38			
A-3	55	35			
B-1	50	32	6	11	3.5
B-2	45	29			
B-3	45	26			
C	40	22	7	15	4
Note	Actual content of U_3O_8 and ThO_2 should be reported for all grades				

Table 4: Quality standard of tantalum concentrates

By-product Recovery

There are a large number of minerals associated with tantalum and niobium, many of them are of economic value. Recovery of these minerals can not only increase revenue, but may also help to improve quality of the main products. So efforts have been made in every plant in this direction. For example, Yichun Mine reclaims lepidolite concentrate using flotation, and reclaims feldspar using a gravity separation method. Keketuohai recovers spodumene, beryl and some stones. The lithium products are important raw materials in the lithium industry. Feldspar is widely used in the glass industry and the ceramic industry.

DEMAND AND SUPPLY

The situation of China's tantalum raw material demand/supply can be described as three periods. The first period covered the years before 1987. This was a period of self-sufficiency. Demand was balanced by supply in the domestic market in most years, but surplus of supply was occasionally observed. In such years, the output of concentrates was more than the amount demanded by the metallurgical processors and the amount of metallurgical products was more than the market could consume, but the surplus was normally small. Imports and exports were very rare in those years.

The years from 1987 to 1994 are considered as the second period. In this time, China exported a certain amount of tantalum products, but the material was principally potassium fluotantalate. Metallurgical processors fundamentally used domestic concentrates, but some amount of tantalum raw materials was imported.

The present period could be considered as starting from 1994. In this period, a rapid increase of tantalum metallurgical product exports is the most important feature, and tantalum powder and wire are the main export commodities. The increase in tantalum raw material imports is another outstanding feature. The export of potassium fluotantalate is also increasing but imported raw materials play the most important role in production of the exported potassium fluotantalate.

We collected some statistics data from 1990 to 1996 and plot them in Figures 8, 9 and 10. These diagrams may help us to survey China's tantalum market over these years.

In Figure 8, the curve 'shipment' is the amount of the tantalum metallurgical product shipped by domestic processors to both the domestic market and international market, but the K_2TaF_7 export is excluded. The curve 'output' is the concentrate output of domestic producers. Here the supply prevails over the demand for all the years before 1994, but in late 1994 demand begins to surpass supply. These curves could be taken as the basic aspect of tantalum raw material demand/supply in China.

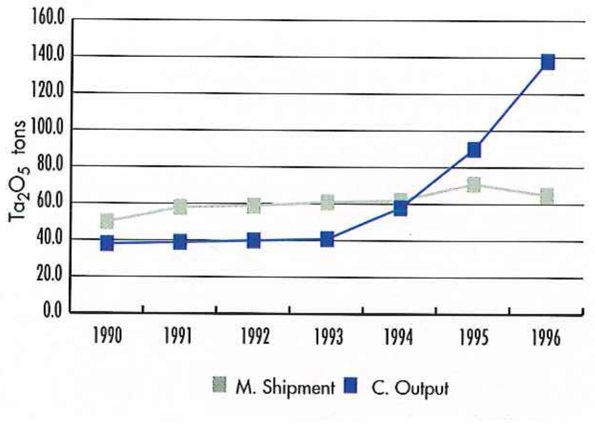

Figure 8: Shipment of tantalum metallurgical products and output of tantalum concentrate

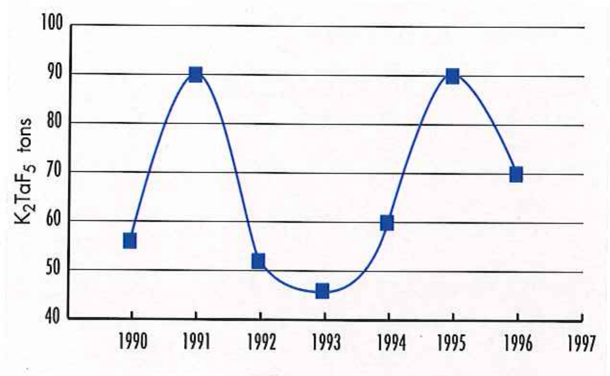

Figure 9: China's potassium fluotantalate exports

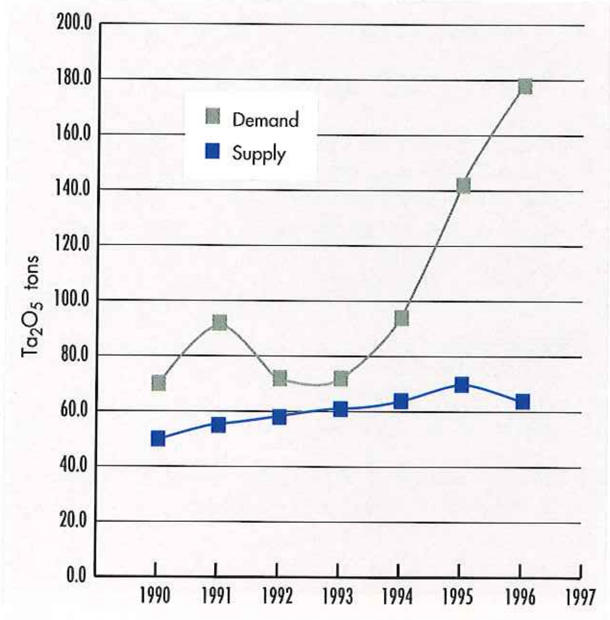

Figure 10: Tantalum raw material demand/supply in China

China's K_2TaF_7 exporting reflects the raw material demand of foreign companies, particularly the foreign processors, on the market in China. However, the export of K_2TaF_7 is a somewhat complex issue. There is no accurate report available about the amount exported, and it is even more difficult to figure out the origin of its raw material. It may come from the mines in China, it may be imported from abroad, or it may be directly supplied by the buyer. We estimated the amount of K_2TaF_7 exported as shown in Figure 9.

Although the curve fluctuates dramatically, we did not find significant fluctuation in raw material demand/supply. The reason may be that imported material and toll conversion form the main portion of the raw material source of exported potassium fluotantalate, the amount coming from domestic producers is a small portion and kept stable.

When we add the potassium fluotantalate export into the metallurgical product shipment and use it as total demand, and we still use the output of the Chinese producers as total supply, the demand/supply pattern of raw material in China's market can be described as shown in Figure 10. Here the demand curve is located above supply, because we did not include other kinds of raw materials, such as recycle material, into the supply. There is no doubt that the supply well met the demand before 1994. The year 1991 was an exception, it saw a large quantity of K_2TaF_7 toll conversion. After referring to Figures 8 and 9, it could be found that it is the metallurgical product shipment, instead of the K_2TaF_7 export, which drove the total demand to a steady increase.

Obviously, the above data also predict the general trend in China's tantalum market.

In the near future, the shipment of tantalum metallurgical products, mainly powder and wire, will continue to increase steadily. The shipment of metallurgical products to international markets will continually increase in the foreseeable years, and its increase in the domestic market will be stable and sometimes brisk. Export of potassium fluotantalate, including toll conversion, will continue to increase for the future years, although the margin may sometimes fluctuate.

It is estimated that the total annual demand for tantalum raw material in China may reach 370 tons of Ta_2O_5 by the year 2000. China was to import tantalum raw material to compensate its demand in the future years, but we have no reason to think that China would only import tantalum raw material. China's tantalum mines are now developing and their total capacity of supply may reach 340 tons of Ta_2O_5 by the year 2000. However in the Chinese market, the demand/supply will be vitally diversified. Firstly, the export of metallurgical products and K_2TaF_7 will be quite brisk. Secondly, it is likely that China's raw material exports will increase when output increases. China's mines have been exporting tantalite concentrates for years; although the quantity was small, the exports never stopped. Thirdly, the importing of raw materials, including tantalum/niobium concentrates, low grade tantalum ores and recycle materials, will continue to be very active. Among all the tantalum related goods that China will import, raw materials will remain the most important for many years. Fourthly, the importing of tantalum metallurgical products can not be neglected. Tantalum consumption in China has gradually increased, this increase will become faster in future years. Metallurgical products, including tantalum powders, wires and other wrought products will be needed not only by Chinese companies, but also by the joint-ventures and foreign companies in China. China has a large increasing potential market for tantalum/niobium wrought products. Therefore imports of metallurgical products will soon have reasonable shares in China's market.

So we believe that China's tantalum market is becoming an open and a diversified market. It will be a market having brisk import and brisk export.

SUMMARY

China contains significant reserves of tantalum natural resources, a number of large scale tantalum/niobium deposits have been found in many provinces. Several mines are now running with reasonable processes. China possesses the necessary conditions to accelerate the development of tantalum raw material production.

The situation in tantalum raw material demand/supply in the China domestic market had maintained balance in the past, although a shortage in supplies took place in the past two or three years because of a sharp increase in demand from processors both in China and outside China. Fast development of the processors will certainly stimulate corresponding development within China's tantalum raw material producers

In China, expansion and advancement happening in the whole tantalum industry, including tantalum raw material production, tantalum/niobium metallurgical processing, as well as in tantalum/niobium application and consumption. All those developments will certainly make China's tantalum/niobium market a diversified open market with both imports and exports prosperous.

ACKNOWLEDGEMENTS

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INDUSTRY NEWS

DLA

The Defense National Stockpile Center awarded at end of October 20 000 lb (contained Ta) in tantalum oxide to Kennametal, Latrobe, Pa., for an approximate market value of $1.3 million. It also awarded 2000 lb (contained Ta) in tantalum carbide powder to H.C. Starck Inc. for an approximate value of $131 000. These sales complete the disposal of tantalum carbide and tantalum oxide under the fiscal year 98 materials plan.

DLA also awarded about 34 000 lb of contained Nb in Fe/Nb to Considar for an approximate market value of $225 000. Additional quantities will be offered next month.

Brazil

The planned privatization of the largest niobium deposit under the state controlled geological service (CBRM) was postponed until February 1998. This delay should allow the discussion with other government agencies regarding environmental and security aspects. This niobium deposit is located in the region bordering Venezuela and will be subject to specific rules.

MEMBERSHIP

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Fax: (852) 2694 8782

Plazaminerals,
4 rue du Mont-Blanc,
1201 Geneva, Switzerland.
Fax: (41) 22 738 62 02

Lydenburg Exploration and Tantalum Mining Corporation of Canada have resigned from membership.

Tantalum-Niobium International Study Center,
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1050 Brussels, Belgium
Tel.: (02) 649.51.58
Fax: (02) 649.64.47
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