Tantalum Mining Corporation's gravity concentrator—recent developments

R. O. BURT
Mill Superintendent
Tantalum Mining Corporation of Canada Limited
Bernic Lake, Manitoba

ABSTRACT

The original flowsheet of the TANCO mill consisted of a simple two-stage gravity circuit for the recovery of the tantalum concentrates. With decreasing grade and grain size of the tantalum minerals, considerable modifications to the circuit have been required.

This paper discusses the various recent improvements carried out on all stages of the flowsheet, which have resulted in a 10% increase in recovery. Future improvements, including on-stream analysis, and the possibility of tantalum flotation, are also discussed.

Introduction

The Bernic Lake pegmatite of The Tantalum Mining Corporation of Canada Limited (TANCO) is, in many respects, unique. Not only does it produce some 40% of the world's supply of tantalum in concentrates(1), but it also contains the world's largest known reserves of cesium and rubidium. Its substantial spodumene reserve consists mainly of refractory-grade high-purity material and it could be a large lithium producer in the near future. The gallium content of the micas in the orebody might also be sufficient to support a gallium separation facility.

Finally, as with all complex pegmatites, it contains substantial quantities of industrial minerals, such as high-purity quartz, feldspars and amblygonite.

R. O. Burt

Richard O. Burt graduated from the Royal School of Mines, London, in 1963 and joined Kilembe Mines Ltd., Uganda, as assistant metallurgist. In 1965, he joined Consolidated Tin Smelters Ltd., being appointed in 1967 as manager of their subsidiary, the Cornish Tin Smelting Co. Ltd., Camborne, Cornwall. In 1972, he joined Bartles (Carn Brea) Ltd., mineral processing equipment manufacturers. As product development manager, he travelled extensively and also published several papers on his specialty subject, fine gravity concentration. Mr. Burt, has been mill superintendent of TANCO since 1977.

Keywords: Tantalum Mining Corporation, Gravity concentrators, Bernic Lake pegmatite, Grinding, Spiral circuits, Sand concentration, Slimes concentration, Screening, Tabling, Flotation, On-stream analysis.

History

The TANCO pegmatite is located about 180 km northeast of Winnipeg, close to the Manitoba-Ontario boundary, on the north shore of Bernic Lake. The nearest service town, and most employee accommodation, is at Lac du Bonnet, 59 km southwest of the mine.

The property was first staked by Jack Nutt Tin Mines Ltd. in 1929 to explore a cassiterite outcrop. Thereafter, the ownership of the property changed hands several times, as did the stage of activity; these have been recorded elsewhere by Howe(2). The ownership of TANCO itself has radically altered over the 10 years of operation—the Goldfield-Chemalloy partnership; then Chemalloy wholly owned; Chemalloy and MDC; Chemalloy and MDC and KBI; and currently KBI, Hudson Bay Mining and Smelting Co., Limited, and MDC.

Mineralogy

The pegmatite is a highly complex orebody, with 65 mineral species already identified. Although several detailed studies of the mineralogy of the deposit have been published(3,4,5), a brief description will result in a better understanding of the metallurgical problems.

The major gangue minerals are silicates, with lesser phosphates and carbonates. Within the tantalum zones in the orebody, the major silicates present are quartz, albite and microcline, and also a large suite of micas, primarily muscovite and lepidolite, with minor and variable quantities of beryl, spodumene and tourmaline. Apatite is the only phosphate mineral present in the tantalum zones.

The 22 identified sulphide minerals account for little more than 0.01% of the ore and can hence be classified together.

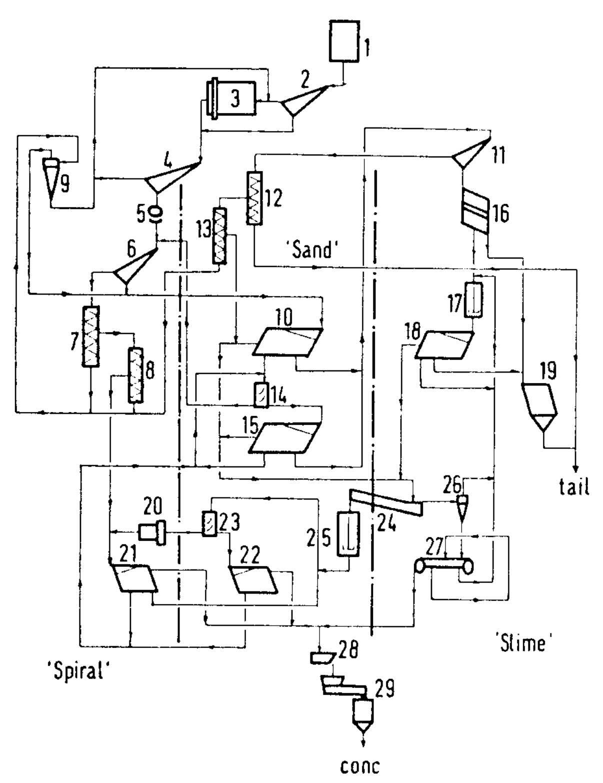
The oxides present in the ore include minor ilmenite and cassiterite, as well as a total of seven different tantalum minerals. These occur within two well-defined areas within the pegmatite, known as the main or shaft orebody and the west orebody. The major tantalum mineral in both orebodies is wodginite, which was shown by Cerna and co-workers(3) to conform to the formula $Mn_4(Sn,Ta,Ti,Fe)_4(Ta\ Nb)_8O_{32}$; ideal wodginite contains 70% Ta_2O_5, 15% SnO_2, 10% MnO and 2% Nb_2O_5. The majority of the wodginite occurs as axehead-shaped crystal assemblages less than 1 mm in size, although some as large as 25 mm have been observed. The west orebody also contains a significant quantity of microlite—$(Na,Ca)_2Ta_2O(O,OH,F)$—with a Ta_2O_5 content of 73%, generally as a thin "smear" on gangue minerals.

The mineral simpsonite—$Al_4Ta_3O_{13}$ (OH)—has recently been positively identified to occur in the west orebody in significant amounts. Tantalite, pseudoixiolite, bismutiotantalite and tapiolite also occur in minor quantities throughout the ore.

In many cases the replacement has not been complete, and particles which appear under the naked eye as discrete tantalum minerals can still contain 50% disseminated gangue, hence exacerbating the metallurgical problems of producing high-grade concentrates with high recovery of a very friable mineral.

The TANCO Concentrator

The original plant design by F. C. Lendrum, metallurgical consultant for the company, was based on testwork carried out by Raicevic[6], of the Department of Energy, Mines and Resources, Ottawa. This testwork indicated that a simple all-gravity plant would be satisfactory, grinding ore to -20 mesh for rougher tabling followed by a regrind of the rough concentrate to -65 mesh for final cleaning.



1. 1500-ton, live, fine ore bins
2. 3-1/2- by 7-ft Tyler screen
3. 8- by 12-ft ball mill
4. 4- by 12-ft A-C screen
5. Magnet
6. Derrick multifeed screen
7. 7 GEC double-start spirals
8. 1 GEC double-start spiral
9. Dewatering cyclone
10. 8 Deister "666" triple-deck tables
11. 2 Derrick multifeed screens
12. 5 GEC double-start spirals
13. 1 GEC double-start spiral
14. 2 Bartles-CTS screens
15. Deister "666" triple-deck table
16. 6 Bartles-Mozley separators
17. Agitator
18. 5 Holman D.D. slime tables
19. Lamella thickener
20. 3- by 6-ft ball mill
21. Deister "6" single-deck table
22. 2 Deister "6" single-deck tables
23. Bartles-CTS screen
24. Screw classifier
25. Holding tank
26. Four 3-in. cyclones
27. Bartles CrossBelt concentrator
28. 2 filter pans
29. Drying system

FIGURE 1. Tanco mill flowsheet.

TABLE 1. Relative table efficiency treating square mesh and wedge wire screen undersize

	% Wt.	% Ta_2O_5	Dist^n. Ta_2O_5
		-SQUARE MESH-	
Conc.	4.2	1.98	77.4
Tail	95.8	0.026	22.6
Head	100.0	0.108	100.0
		-WEDGE WIRE-	
conc.	4.4	1.57	67.5
Tail	95.6	0.035	32.5
Head	100.0	0.103	100.0

The ore used by Raicevic in his testwork graded 0.31% Ta_2O_5; head grade to the mill for 1979 will average 0.14% Ta_2O_5. Lower head grades and a finer liberation size, along with considerable operating experience, have necessitated many major changes to the original plant flowsheet. The present flowsheet is shown in Figure 1. Run-of-mine ore is crushed in three stages to -12 mm and stored in three 500-tonne fine ore bins, two of which are generally drawn simultaneously to provide a blended feed to the concentrator. There are basically three concentration circuits within the plant flowsheet—coarse concentration by spirals, mid-size on tables and spirals, and fine sizing in the slimes plant. All are interconnected, with at least part of the tailing from one circuit being reprocessed in the next.

With such a low-grade feed, requiring enrichment of the order of 300:1, no attempt is made at single-stage concentration. In each circuit, stage concentration is employed, with rougher cleaner and even recleaner stages. Apart from improving the metallurgy, it also enables supervision to be reduced, and only two operators are required per shift.

A recent paper[7] has described various phases in the evolution of the concentrator flowsheet. Consequently, only recent modifications leading to the present flowsheet will be described in this paper.

Coarse Concentration

The original testwork carried out by Raicevic indicated that, after grinding the ore in closed circuit to 20 mesh, concentration, on shaking tables, could efficiently be carried out, without further classification into various fractions. Consequently, plant design and operation was simple, compared to the more complex gravity plants common in Cornwall[8] and elsewhere.

The tantalum minerals, by virtue of their high specific gravity (approx. 7) and friability compared to the harder gangue minerals, do not respond to hydraulic classification, with excessive slime production resulting. Consequently, sizing in the grinding circuit has been carried out exclusively by screening.

The original 500-tpd flowsheet called for two 300-mm wide DSM screens to size mill discharge at 20 mesh. With lower head grades, the plant capacity was increased to 700 tons per day, and final liberation size dropped to 60 mesh. This increased tonnage at finer grind size was achieved, in 1974, by converting the rod mill into a grate discharge ball mill.

Various types of screens have been installed at various times, including flat wedge wire-screens, DSM screens, both rapped and un-rapped, and Bartles-CTS screens; however, the oversize returning to the mill always contained excessive fines. While giving no cleaner oversize, the square mesh of the Bartles-CTS screen produced an undersize with fewer flat particles, more amenable for tabling (Table 1).

While grinding to 60 mesh was required to liberate all of the recoverable tantalum minerals, any mineral liberated coarser than 60 mesh was being returned to the mill and consequently slimed. To determine the top liberation size of the tantalum, heavy liquid separation testwork was carried out on a representative sample of the ball mill discharge. The heavy liquids used were Clerici solution at a s.g. of 4.2 and 1, 1, 2, 2-tetrabromethane (TBE) at 2.96. The techniques employed have been fully described by Mills[9].

The testwork confirmed the presence of a substantial amount of liberated tantalum coarser than 65 mesh (Fig. 2). Indeed, the top size of liberation, -20 mesh, had not significantly changed from Raicevic's original work.

A two-stage grind was indicated; however, with the constraint of the one mill an alternative was required, and in-plant testwork was carried out on the circulating load, treating the material on spiral concentrators. This work showed that by treating the -20 mesh fraction of the circulating load, up to half of the total plant concentrates could be produced from a spiral circuit, and over-all plant recovery would increase by

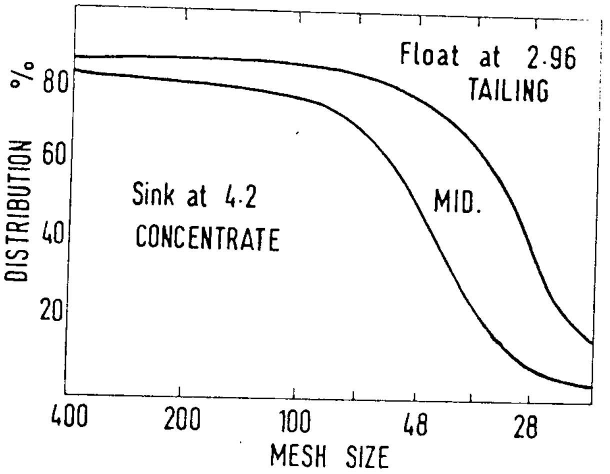


FIGURE 2. Heavy-liquid testwork on sized ball mill discharge, showing final liberation size of tantalite at 65 mesh.

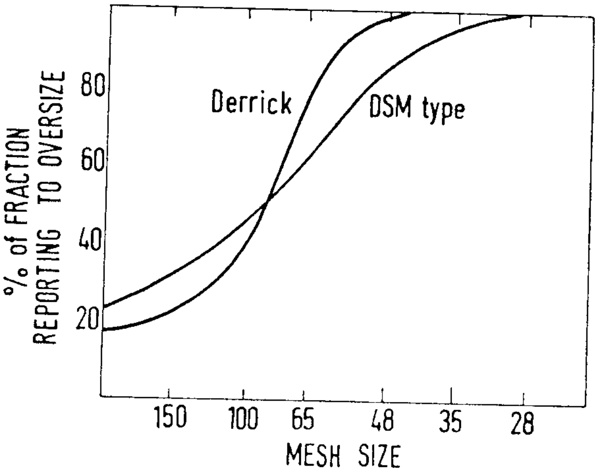


FIGURE 3. Relative efficiency of Derrick and DSM screens, sizing Allis-Chalmers screen undersize at 65 mesh.

over 2%, amply justifying the decision to install the full spiral circuit.

Spiral Circuit

One Allis-chalmers low-head 4- by 12-ft screen sizes ball mill discharge at 20 mesh in series with one Derrick Multifeed screen sizing at 60 mesh, the grinding iron being removed by a low-intensity magnet between screening stages.

Having proved to be the best fine wet screen tested by TANCO, the Derrick screen is worthy of a short description. It consists of a screening surface supported on a frame to which is transmitted a high-speed, low-amplitude vibration (3,600 vibrations/minute), obtained from a low-power, totally enclosed 3-phase induction motor fitted with rotating eccentric-bearing housings. The motor is mounted above the center of the screen, and a vertical elliptical action is obtained which accelerates the material at the feed end and slows it at the discharge end. The high-frequency low-amplitude impact (5 g) to the screen frame assures close contact of the flowing film with the screen surface. The vibration is isolated from the bearers by float mounts to avoid transmitting energy to the building structure and to ensure that only the imposed frequency prevails. For making separations in the -30 + 300 mesh range, the deck consists of two superimposed and equally tensioned stainless steel wire cloths supported in crown tension to obtain uniform action over the entire surface and to avoid flutter and fatigue. This "sandwich" construction results in a slight relative movement of the top and bottom cloths, thereby avoiding blinding, and makes possible the use of heavier-gauge wire than is conventionally used in the manufacture of cloth of the same aperture.

The screen is fed to absolute maximum capacity; even so, its performance outstrips all earlier tested units in terms of sharpness of separation (Fig. 3). The cost of screen cloth is undoubtedly higher than that of other units, at 6.5¢/ton; however, the increase in screening efficiency entirely outweighs this cost.

Seven double-start GEC spirals treat the full circulating load, which averages 30 tons per hour, but varies depending on the mineralogy of the ore. These give an 8:1 enrichment with a 50-55% recovery. One double-start cleaner spiral further upgrades this by 3:1, rejecting only a further 3% of the tantalite and reducing the total quantity of spiral concentrate to that suitable for final cleaning on one Deister sand table. To treat the coarse fraction, this table has been fully riffled with brass riffling. Typical performance of the spiral circuit is given in Table 2.

TABLE 2. Typical spiral circuit performance

Product	Weight (T.P.H.)	Weight %	Assay (% Ta_2O_5)	Distribution Units	Distribution %
Final Spiral Circuit Conc.	0.031	0.1	49.17	1.523	50.6
Cl. Table Tail	0.535	1.8	0.282	0.151	5.0
-(Spiral Cl. Conc.)	(0.566)	(1.9)	(2.96)	(1.674)	(55.6)
Spiral Cl. Tail	1.564	5.2	0.051	0.080	2.6
-(Rghr. Spiral Conc.)	(2.13)	(7.1)	(0.823)	(1.754)	(58.2)
Rghr. Spiral Tail	27.87	92.9	0.045	1.258	41.8
HEAD	30.0	100.0	0.100	3.012	100.0

TABLE 3. Typical plant metallurgical balance

	Weight T.P.D.	Weight %	Assay (% Ta_2O_5)	Distribution (%)
-Spiral Cl. Conc.	0.683	0.09	50.26	29.5
-Sand Cl. Conc.	0.673	0.09	54.48	31.5
-Slime Cl. Conc.	0.314	0.04	42.09	11.4
(TOTAL CONC.)	(1.67)	(0.22)	(50.46)	(72.4)
-Sand Tailing	445.0	61.4	0.034	13.0
-Slime Tailing	278.3	38.4	0.061	14.6
(TOTAL TAILING)	(723.3)	(99.8)	(0.041)	(27.6)
HEAD	725	100.0	0.147	100.0

No attempt is made at this stage to produce a final tailings from the spirals; their sole purpose is to recover free and lightly locked tantalite within the circulating load, returning heavily locked material to the grinding circuit. Further locked material is returned to the grinding circuit from cleaner table tailings.

The spiral circuit went on line in July 1978, and significant quantities of coarse free tantalite are produced from this circuit. A typical plant metallurgical balance (Table 3) shows the distribution of recovery between this and the other circuits.

More recently, a 3-1/2- by 7-ft Tyler screen has been installed on the ball mill feed. This unit screens at 3 mm, further reducing the possibility of overgrinding of any free tantalum minerals in the mill heads. Definitive results are not yet available.

Sand Concentration

As stated earlier, the original plant design called for a simple concentration circuit, tabling the -20 mesh ground product without further classification. However, with the installation of the spiral circuit, coupled with the finer grind, the easily recoverable coarser tantalite has been removed prior to the tabling circuit, and this circuit, while receiving lower-grade material, suffered an apparent loss in efficiency

TABLE 4. Comparative fractional tailing assays, as % Ta_2O_5

Size (Tyler Mesh)	Actual Plant Performance	H. Liquid Floats at 2.96	Lab. Tabling Testwork "As-Is"	Lab. Tabling Testwork Deslimed at 400 m	Lab. Tabling Testwork Classified	Scav. Spirals
+48	0.039	0.032	0.031	0.030	0.027	0.034
+65	0.024	0.011	0.028	0.028	0.027	0.017
+100	0.022	0.010	0.027	0.022	0.017	0.013
+200	0.021	0.007	0.026	0.016	0.013	0.006
+400	0.033	-	0.032	0.031	0.030	0.020
-400	0.120	-	0.208	0.101	0.191	0.102

Heavy-liquid separation of plant tailings at an s.g. range of 2.7-3.4 indicated excessive losses in the -65 +200 mesh range. Small-scale testwork using a Deister laboratory table duplicated plant performance, confirming that the problem was metallurgical rather than mechanical.

Three possible routes were examined—simple removal of the -400 mesh fraction prior to tabling, in an attempt to lower viscosity drag; classification of deslimed material into four fractions, tabling each separately; and retreatment of the +400 mesh table tails on further spiral concentrators. The comparative efficiency of the various routes was based on the closeness to the "theoretical" tailing achieved by heavy-liquid separation at 2.96 (Table 4).

Classification of the material undoubtedly gave superior results to straight tabling, with or without slimes removal. However, retreatment of the +400 mesh table tailings by spiral concentrators proved to be the most efficient route. Apart from the purely metallurgical reasons, this latter route had the advantage of requiring far less additional water (hydroclassifiers are notable water users) and allowing a "safety-valve" in case of the malfunctioning of any part of the tabling circuit. A total of six more GEC double-start spirals were therefore installed alongside the coarse spiral bay, and these came on-stream late in January 1979.

TABLE 5. Typical performance of scavenger spirals

Product	Weight T.P.H.	Weight %	Assay (% Ta_2O_5)	Distribution % Stage	Distribution % Over-all
Scav. Cl. Conc.	0.138	0.8	0.575	12.4	1.9
Scav. Cl. Tail	1.322	7.2	0.042	8.7	1.3
Scav. Tail	16.84	92.0	0.030	78.9	12.1
Scav. Spiral Head	18.3	100.0	0.035	100.0	15.3
Mill Head	30.0	-	0.140	-	100.0

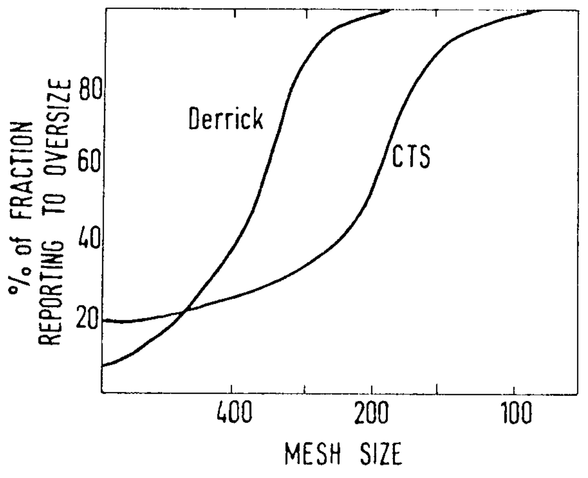


FIGURE 4. Comparative performance of Derrick and CTS screens, screening 30 tph of rougher plant tailings; CTS screen sizing at 200 m, Derrick screen at 400 m.

Results from the scavenger spiral circuit are given in Table 5, which indicates that the increase in over-all recovery to rougher concentrate is of the order of 2%. Allowing for losses in the cleaning of this material to "sellite" grade, it is probable that this scavenger circuit contributes upward of 1.5% extra recovery in the plant.

Slimes Concentration

Although the Deister rougher tables, latterly in conjunction with scavenger spirals, have given a good recovery of the +400 mesh (liberated) tantalite, their performance on the fines was always poor, with recovery rarely exceeding 5% of the -400 mesh material. Typically, nearly two-thirds of the tantalite in the rougher tailings would be contained in the one-quarter of the weight finer than 400 mesh.

Hence, the need for retreatment of the rougher tailings to recover slime tantalite was recognized early in the plant life, and testwork was indeed carried out in 1970 on a pilot scale, and also in 1974. The project was reactivated in 1975 and, after a research program at Lakefield Research of Canada Limited, a three-stage slimes plant was installed later that year to treat screen undersize from rougher tailings.

The screens originally installed were 6 Bartles-CTS screens, latterly with nylon cloths. However, blinding continued to be a serious problem, and various other units have been tested, with even less success (Table 6). On the average, the CTS screens gave a 50:50 weight split, with only a slight upgrading, and with 60% of the total tantalum in the rougher plant tailing (70% of the -400M Ta_2O_5) passing to the slimes plant.

Again, the Derrick screen has proved to be the most efficient unit, and two such screens were recently installed. Whereas the other units were not capable of any sensible sizing finer than 200 mesh, (74 microns), these two Derricks are now sizing at 45 microns. Not only is the size of separation considerably reduced, the sharpness of cut is increased (Fig. 4). Hence, although less over-all tonnage passes to the slimes plant, it is of significantly higher grade, and 65% of the total tantalum in the rougher plant tailings (and over 80% of the -400 mesh Ta_2O_5) reports to the slimes plant. Further screening efficiency will be achieved with the installation of a third Derrick screen in parallel.

TABLE 6. Relative performance of fine sizing units

	No. Units Required	T.P.H. to Slime Plant	Recovery (-400 m Ta_2O_5)	Misplaced U/Size	Misplaced O/Size
CTS Screen	6	14	70%	42%	10%
Bauer Hydrasieve	20	7		45%	21%
Screw Classifier	1 x 54"	15	83%	30%	47%
Derrick Screen	2	11.5	87%	24%	4%

Primary concentration employs six Bartles-Mozley Separators in parallel, rejecting the "non-recoverable" fraction of the material, (mainly -10 micron slimes and true gangue). The enrichment ratio is low, however, at approximately 3:1, and the rough concentrate is upgraded by a further 8:1 on 5 Holman double-deck slime tables, also in parallel.

As originally supplied and installed, these tables were incapable of sustaining good recovery, with stage recovery rarely exceeding 30%. However, by adding brass riffling and painting the linoleum deck surface with urethane, and also modifying the spring tension ratio, stage recovery now exceeds 70%.

Final cleaning of the slimes, originally carried out on a Deister slime table, is now generally carried out on a Bartles CrossBelt concentrator. For further details of the operation of the concentration devices used in the slimes plant, the reader is referred to Burt and Stoelzle(10).

One of the major causes of inefficient slimes plant performance was the "sawtooth" in feed flow rate caused by the blinding of the CTS screens and their regular cleaning by high-pressure air/water jets; stability in the slime circuit was never attained. With the Derrick screens fully operative, this has been overcome, and slimes plant efficiency has improved accordingly.

Typical slimes plant performance, before and after the various improvements were carried out, is given in Table 7.

TABLE 7. Typical performance of slimes plant

1977

	% Wt.	**% Ta_2O_5**	**Distribution**
Final Conc.	0.01	35.0	8.4
Deister Tail	0.29	0.41	2.1
Holman Tail	11.7	0.125	23.8
Mozley Tail	38.7	0.045	28.1
CTS O/Size	49.3	0.045	37.6
Rougher Tail	100.0	0.061	100.0

1978

	% Wt.	**% Ta_2O_5**	**Distribution**
Final Conc.	0.03	42.50	25.5
X Belt Tail	0.67	0.24	2.7
Holman Tail	5.7	0.095	9.3
Mozley Tail	32.5	0.047	26.6
Derrick O/Size	61.1	0.035	35.8
Rougher Tail	100.0	0.058	100.0

Flotation

Although the performance of the gravity slimes plant has improved significantly over the past twelve months, it is still the area of major loss of tantalum from the plant. With the high price of the product, every potential method for increasing recovery is being investigated and a program of research into possible routes for the flotation of tantalum is underway.

Not surprisingly, considering the relative scarcity of the mineral, little attention has been given by research workers to the flotation of tantalum. Practically all of the limited work that has been carried out is in the U.S.S.R., where several potential routes have been investigated in the laboratory. Latterly, the main reagent tested has been based on hydroxamic acid, and one worker(11) has claimed both high recovery and enrichment. However, at a pH approaching 0.1, the economics of the route would be hard to justify. Nevertheless, in the spirit of true international cooperation so apparent in the mining industry, work is being carried out, concurrent with our own, at the Meckanobr Institut in Leningrad to determine whether their procedures can be used on TANCO's slimes.

Several reagent suites have been examined at TANCO, including fatty acids, hydroxamic acids and cationic reagents, as well as various modifiers. None gave results of practical value. Work is now centred on the use of the sulphosuccinamate reagent, first patented by Arbiter and Hinn(12) for cassiterite flotation and more fully researched for that mineral by Collins *et al.*(13).

A typical bench-scale result, when floating Bartles-Mozley separator concentrate, as shown in the schematic flowsheet (Fig. 5), is given in Table 8. However, a more practical application will be on the slimes plant feed, and research is now centred on this material. Recovery from the deslimed feed exceeds 80%, and work is currently aimed at improving final concentrate grade.

TABLE 8. Bench-scale flotation of Bartles-Mozley rougher concentrate

Product	**% Wt.**	**% Ta_2O_5**	**Distribution**
Float Conc.	2.14	7.87	72.6
Gravity Conc.	0.12	11.25	5.8
TOTAL CONC.	(2.26)	(8.04)	(78.4)
Cleaner Tail	8.54	0.190	7.0
Rougher Tail	89.20	0.038	14.6
HEAD	100.0	0.232	100.0

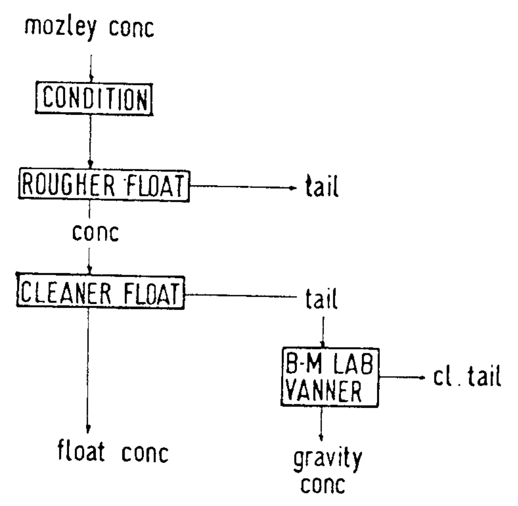


FIGURE 5. Schematic flowsheet of bench-scale tantalite flotation.

Fundamental studies, using gram-scale flotation procedures, are also in hand to determine the effect of the collector on the various mineral species, with and without various activating or depressing ions present. Details of this work will be published later.

Analytical

When the mine was being developed, fast, reliable and accurate methods of low-grade tantalum analysis were not available. Although a variety of essentially wet methods were in use within the industry, the complexity and time requirement were incompatible with the rapid turn-around needed in mine and mill control.

TANCO consequently contracted X-Ray Assay Laboratories to develop an X-ray fluorescence technique for the determination of tantalum and other metals in both ores and concentrates. The procedures which were developed have been very successfully employed at TANCO since the earliest operating days, with accuracy on low-grade ores and tailing being about .001% Ta_2O_5. Some measure of the success of the technique is that the majority of buyers of tantalum concentrates, as well as independent assay laboratories, now use X-ray fluorescence analysis techniques. An essential step in this method is the comminution of the sample to a fine, relatively homogeneous powder before measurement.

The laboratory is equipped with a Philips PW 1220 semi-automatic X.R.F. system for the analysis of Ta_2O_5, SnO_2, Cb_2O_5 and TiO_2 on a regular basis. A Philips PW 1540 unit is maintained on a back-up basis and for research analyses of gallium, rubidium, cesium and P_2O_5. Lithium and other alkalies are analyzed on a Perkin-Elmer 305B atomic absorption spectrophotometer.

The analytical laboratory operates on day-shift only, and hence mill metallurgical accounting is carried out on 24-hour turnaround analyses. With increased complexity of the circuit and enhanced value of the products, the need for rapid, multistream analyses became desirable. Although the vanning shovel, or plaque, is used in the mill for rapid visual determinations of heavy mineral content, it cannot be used as a control device for the very low-grade tailing streams.

On-stream analysis was the logical answer to the requirements and a study of the various systems on the market was therefore carried out. Early testwork soon indicated that the use of radioisotopes for X-ray generation would not give sufficient flux for accurate analysis of tailing streams in dilute pulps, thereby eliminating the possibility of using any multihead, or in-stream, analysers.

Even with a standard X-ray tube and generator, difficulties occurred when attempting to apply normal XRF analytical techniques to the analysis of the relatively coarse, natural materials in the form of process pulps. With the very low content of the element sought, together with a matrix which gives rise to substantial back-scatter intensity close to the energy of Ta characteristic X-rays, very low signal-to-noise ratios result. The high self absorption within the comparatively coarse host grains also posed a problem in rendering the measurement highly particle-size dependent.

However, a study carried out in the laboratories of GEC-Elliott Process Instruments, England, demonstrated that, using information derived from the intensity of a back-scattered, essentially monochromatic, primary X-ray, together with the transmitted intensity of a high-energy gamma-ray, these problems could be resolved.

Following from this work, a GEC "Mintek On-Stream Analytical System" has been ordered and will be commissioned later this year. This unit has been fully described elsewhere(14). From the results obtained during the laboratory investigation, this system will be capable of determining tantalum in the tailing streams with an accuracy of 0.005% or better. Initially, the system will monitor tantalum in seven tailing streams, with a cycle time in the order of 20 minutes. It is capable of expansion, however, both as regards the number of streams to be analyzed and the number of elements to be determined.

It is anticipated that the rapid availability of assay data on the tailings streams thus provided will greatly assist in maintaining optimum operating conditions in the plant, increasing recovery accordingly, with consequent economic benefits.

Conclusions

This paper has discussed various improvements made to the TANCO gravity mill over the last year of operation, which have typically improved recovery from 60% to over 70%. The major areas of improvement can be summarized as follows:

(a) SCREENING—The installation of Derrick screens has resulted in better sizing, reducing overgrinding of the very friable tantalite minerals.

(b) SPIRALS—The installation of a spiral circuit to recover the tantalite as soon as it is liberated has increased recovery by 5%.

(c) SLIMES CIRCUIT—Various improvements to the circuit have doubled stage recovery, increasing over-all plant recovery by approximately 3%.

Acknowledgment

The author wishes to record his appreciation to the entire crew at TANCO, whose tireless efforts enabled the various major modifications described above to be brought on line and optimized, on target in each case. Permission to publish this paper given by the management of The Tantalum Mining Corporation of Canada Limited is also gratefully acknowledged.

REFERENCES

1. T.I.C., *Quarterly Bulletin, No. 14, June 1978.*
2. HOWE, A. C. A., Canada's First Tantalum Producer, *Western Miner, Dec. 1968.*
3. CERNA, I., CERNY, P., CROUSE, R. A., FERGUSON, R. B., GRICE, J. D., MACEK, J. J., and RINALDI, R., The Tanco Pegmatite at Bernic Lake, Manitoba, I-VIII, *Canad. Mineralogist, II, Part 3, pp. 591-734, 1972.*
4. NICKEL, E. H., The Mineralogy of the Bernic Lake Pegmatite, Southeastern Manitoba, *Dept. of Mines, & Tech. Surveys, Mines Branch Tech. Bull. TB20, 1961.*
5. CROUSE, R. A., CERNY, P., TRUEMAN, D. L., and BURT, R. O., The Tanco Pegmatite, Southeastern Manitoba, *CIM Bulletin, Vol. 72, No. 802, pp. 142-151, February 1979.*
6. RAICEVIC, D., Concentration of Tantalum from the Bernic Lake Pegmatite Deposit, *CIM Bulletin, Vol. 61, No. 680, pp. 1439-1444, Dec. 1968.*
7. WILLIAMS, C. T., *et al.*, Tantalum Mining Corporation of Canada Limited—Bernic Lake Concentrator, *Milling Practice in Canada, CIM Special Volume 16, 1978.*
8. OSBORNE, D. G., Mineral Processing in Cornwall, *Min. Mag., Vol. 128,(4), pp. 246-264, 1973.*
9. MILLS, C., Mineralogy and Heavy Liquid Analysis in Gravity Separation, *presented at Gravity Technology short course, Reno, NV, 1978.*
10. BURT, R. O., and STOELZLE, H., Recovery of Fine Tin Ores by Gravity Concentration, *presented at International Tin Symposium, La Paz, Bolivia, 1977.*
11. KOIKOV, E. I., GLAZUNOV, V. N., TINNOV, A. A., ZAVIALOV, B. A., and SHEMIAKIN, U.S., Experimental Application of Froth Finishing of Tantalum-bearing Gravity Concentrates, *Tsvetsnye Mettal., Vol. 6, pp. 81-83, 1977.*
12. ARBITER, N. A., and HINN, R., *British Patent 1,110,643, 1967.*
13. COLLINS, D. N., HOLLICK, C. T., and JOY, A. S., The Recovery of Fine Tin by Flotation: Some Recent Developments, *Second Technical Conference on Tin, Bangkok, pp. 983-1005, London, ITC, 1970.*
14. Anon., On-stream Analytical System Improves Mill Performance at Geevor Mine, U.K., *Mining Mag., Vol. 137, pp. 19-23, July 1977.*

Symposium on geochemical exploration for uranium

On **November 4, 1979**, the Association of Exploration Geochemists and the U.S. Department of Energy will be sponsoring a symposium on "Geochemical Exploration for Uranium". The symposium will be held in conjunction with the Annual Meeting of the Geological Society of America in San Diego, California.

For further information, contact R. H. Carpenter, Department of Geology, University of Georgia, Athens, Georgia, 30602, U.S.A.