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MICROFILMED

INSPECTION OF SOUTH EAST ASIAN ALLUVIAL

TIN MINING OPERATIONS

JUNE 1979

OPEN FILE

Adrian Fleming
July, 1979
A. Fleming

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INSPECTION ON SOUTH EAST ASIAN TIN MINING OPERATIONS

JUNE 1979

Introduction

The South-East Asian tin province, an area extending from Yunnan through Burma, Thailand, The Malay peninsula and the Indonesian islands of Bangka and Belitung, is the world's greatest stanniferous province. Malaysia and Indonesia produce 30 and 25% respectively of world mine production of tin.

During 25 June - 4 July I was fortunate to visit tin mining operations in three areas within the province - viz. in Malaysia the Kinta Valley near Ipoh and Kuala Lumpur, and the Indonesian Island of Bangka. Inspections were made of various types and scales of tin mining operations including:

- dredging
- hydraulic mining (monitor/gravel pump)
- dry mining (utilizing shovels/truck, etc.)

Discussions were also held with geologists from the Malaysian Geological Survey, Ipoh.

The general objective of the visit was to enhance my understanding of the geology, evaluation, and exploitation methods of alluvial tin deposits. Particular attention was paid to geology, drilling and evaluation methods. I also attempted to document mining and treatment methods and whenever possible obtain operating costs. Approximately half a day was spent at each mine, except for the Koba Tin operations on Bangka Island, where 1½ days were spent. The following commentary therefore only presents an overview which is often simplified and no doubt contains many errors and some contradictions. I hope nevertheless that the data may be useful for our North-Eastern Tasmania alluvial tin operations.

All grades are quoted in Kg SnO_2/m^3, a value of lbs SnO_2/yd^3 is shown in brackets and costs are in Australian dollars. Production is quoted in metric tonnes. The following conversion factors were used:

1 kati = 1.33 lb
16.8 piculs = 1 metric tonne
1 Kg SnO_2/m^3 = 1.69 lb SnO_2/yd^3
1 yd^3 = 0.76 m^3
Malaysian \$2.40 = Australian \$1.00
U.S. \$1.10 = Australian \$1.00
Tin price A\$1066 tonne cassiterite (70% Sn)

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A detailed summary is given below of each operation visited.

Table 1 provides details of ownership, type of operation and personnel met for each operation. Table 2 attempts to provide a comparative summary of all operations visited.

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SUMMARY

The geology and genesis of alluvial tin deposits is poorly understood. Little attention is paid to this aspect of the deposits.

Drilling, grade and reserve calculation methods are similar to those being used by Amdex. The bangka or cable tool percussion drilling method under-values deposits. Although no quantitative data was available, reserve grades calculated from drilling are thought to be, say, 80% of actual contained cassiterite, but drill grades can be as low as 20% of contained cassiterite grade!

The relationship between drill indicated grade and grade of material recovered by mining is poorly documented. In general grade of material mined is higher than drill indicated grade, a ratio of say 1.2 : 1.

Most gravel pump/monitor mines utilise palongs as a primary concentrating method. Stanniferous alluvials from the palong are treated by jigs.

Most tin sheds utilise magnetic and electrostatic separators to treat cassiterite concentrates.

Head grades for monitor/gravel pump mines are similar or higher than current head grade at Pioneer.

Operating costs per cubic metre for monitor/gravel pump mines are slightly lower than Pioneer. The notable exception is P.T. Koba Tin on Bangka Island.

TABLE

MINES VISITED

AREA/NAME	OWNERSHIP/ MANAGEMENT	OPERATION TYPE/MINING METHOD	PRODUCTION Tonnes SnO_2/mth	PERSONNEL
KINTA VALLEY				
Batu Gajah	Southern Malayan Tin Mines P.L., now owned and managed by Pernas Charter Management Snd.Bhd.	Old, well established, large, systematic operation 4 dredges	78	Bill Freyer - manager
Tong Seng (Gopeng)	Chinese partnership - Tong Seng	Small, traditional, Chinese run, scavenging operation, poorly equipped, non systematic Monitor/gravel pump/palong/jig	? ? 5-10	-
Serem Malaysia Sungkai section	Serem, France	Recently developed, small scale, systematic operation Monitor/gravel pump/palong/jigs	4.2	Chan Foo Khee - consultant operations manager
Gopeng Consolidated	Osborne & Chapel P.L.	Old, well established, large, systematic operation Monitor/gravel pump/palong/jig OR Backhoe/dragline/truck/palong/jig	155	George Poon - planning engineer
KUALA LUMPUR				
Sungei Besi	Pernas Charter Management Snd.Bhd.	World's largest open cut alluvial tin mine, very old mine, recently re-opened, tightly run, sophisticated, systematic, modern operation Backhoe/dragline/trucks/jigs	180	Chong Nei Hey - assistant manager

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TABLE

MINES VISITED

AREA/NAME	OWNERSHIP/ MANAGEMENT	OPERATION TYPE/MINING METHOD	PRODUCTION Tonnes SnO_2/mth	PERSONNEL
KUALA LUMPUR				
Ayer Hitam	Pernas Charter Management Snd.Bhd.	Old, large, well established, systematically operated 3 dredges	223	Boon - mining engineer
Syarikat Trimal	Chinese partnership	Recently re-opened, Chinese style operation, partly systematic, no technical staff Backhoe/bulldozer/monitor/gravel pump/palong/jig	120-170	? - Chinese mine manager
BANGKA ISLAND				
P.T. Koba Tin	CSR - BMI - PN Timah Indonesia	Recently opened, large, systematic, well run operation Bulldozer/monitor/gravel pump/palong/jig 2 small dredges	300	R.J. Jackett Simpson - mine manager Malcolm Gilfillan - assistant chief geologist

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TABLE

MINES VISITED

AREA/NAME	OWNERSHIP/ MANAGEMENT	OPERATION TYPE/MINING METHOD	PRODUCTION Tonnes SnO_2/mth	PERSONNEL
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OPERATIONS VISITED

KINTA VALLEY/IPOH

BATU GAJAH

Batu Gajah is the centre for several dredging operations in the Kinta Valley, south of Ipoh, which are now controlled by Pernas Charter Management, a group which is made up of the Malaysian Government, Charter Consolidated, Anglo-American and the Associated Mines group.

The Batu Gajah operation consists of four dredges. An inspection was made of dredge TT 5, built in the 1930's and renovated in 1974. Replacement cost of this dredge is $10 million.

Dredge TT 5 is currently working old dredge tailings to an average depth of 23 metres. Depth variation is 20 to 31 metres on a limestone bottom which is very variable. Head grades currently being mined vary from 0.0036 (0.06) to 0.053 (0.09) kg/m^3 delineated from boring on 160 metre or 80 x 160 metre grid.

Dredge TT 5 is the largest on the property. It consists of:

0.51 m^3 buckets, 26 buckets/minute, 790 m^3/hour, maximum depth 32 metres, 2000 installed horsepower, entirely electric, 14 persons per shift.

Alluvials are processed as follows:

Revolving screen 3.2 metres diameter, 9 revs/minute - 48 primary jigs, 2 cells 6 x 6 ft, 156 strokes/minute - 8 secondary jigs, 2 cells 2 x 2 m. 180 strokes/minute, haematite ragging.

Mining is being carried out on the 366 metre face.

Production figures for May were:

349000 m^3 mined, 20 tonnes of cassiterite recovered, head grade 0.04 kg/m^3 (0.07), bore value for the area 0.29 (0.5) kg/m^3, bucket fill efficiency 81%, running time 86.4%.

All up TT 5 dredging cost is 32¢/m^3 (24¢/yd^3).

During the 11 month period July 1978 to May 1979 the four dredges operated at Batu Gajah recovered 863 tonnes of cassiterite from 11.9 million m^3 of alluvials with an average grade of 0.07 (0.12) kg/m^3. Revenue from sales was $5.92 million, profit after overheads and operating costs was $2.5 million.

Plate 1

Batu Gajah
Dredge TT 5

Plate 2

Batu Gajah
Cassiterite concentrate bins from dredge TT 5

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TONGSENG

The Tongseng Mine is a very small, scavenging operation near Ipoh. This Mine is being operated by a Chinese partnership and is characteristic of small scale Chinese operations.

The ground being worked consists of alluvials on the edge of an open pit which had been worked previously. Four monitors were in operation. One was involved with stripping approximately 6 metres of overburden and the remaining three were washing stanniferous alluvial material down to a gravel pump. Base material is limestone with many pinnacles and so the operation was very small scale. Two gravel pumps were required to pump alluvial material to the revolving screen and palong. Four small primary and two secondary jigs were installed. These are activated for one day each week when the palong is cleaned up.

Plate 3

Tongseng
General view of mining operations. Overburden stripping in background, note mining using 3 monitors and 2 gravel pumps in series.

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SEREM MALAYSIA - Sungkai Section

This small gravel pump mine is located near the town of Sungkai in the Kinta Valley. The mine is 100% owned by Serem Malaysia and managed by mining consultants K.K. Lim & Associates of Ipoh.

The property was acquired by Serem through exchange with another Company for dredgable land. Some areas in the property have previously been dredged. Mine offices including a tin shed were acquired with the property.

The Mine was opened in November 1978 after drilling and assessment by Serem. Capital cost was $84,000. A substantial amount of the heavy equipment used for the operation is being leased.

Six metres of wash and alluvium exist over a decomposed black shale basement which is fairly flat. Tin appears to be distributed throughout all the alluvial section, but in the pit wash was evidently developed in lenses which do not show horizontal continuity. Reserves were not given. Grade from drilling broadly spaced lines of closely spaced holes is 0.14 (0.24) kg/m^3. Seven years reserves have been proven at a quoted production of 38,000 m^3/month. It is evident that approximately 450 tonnes of contained cassiterite have been delineated.

Four monitors are being used in the pit to break down the material and move it to a 15 cm Malayan gravel pump powered by a 354 hp diesel engine. Bowl and impellar changes on the Malaysian gravel pump are necessary every two months. Tin alluvials were being washed a distance of 70 metres from the face to the gravel pump and approximately 160 metres from the gravel pump to the plant with a head of approximately 12 metres.

The plant consists of a revolving screen approximately 1 metre in diameter and 4 metres long from which material washes over a 10 lane palong with a gradient of 1:16. The wooden palong is about 20 metres long and each lane is approximately 1.3 metres wide with riffles every 2 metres. Tailings from the palong are pumped to a tailing pond by a 250 hp gravel pump.

Clean ups are carried out once each week of the whole palong or of individual palong lanes each day. The riffles are removed and tin bearing alluvials sluiced down to a gravel pump. From the gravel pump, material is processed in a small plant as follows:

> 0.46 m cyclone (capacity 1000 gallons/minute) - 2 x 2 cell primary jigs
> 1 x 2 cell secondary jigs, all cells 1.2 x 1.2 m.
> Tails from primary jigs recirculated over palong.
> Secondary jig product 10 to 15% SnO_2.
> Recoveries on the jig plant are in order of 95%.
> No recoveries were given for the palong.

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Working hours are 5.30 to 9.30 p.m. each day. At the beginning of each day dewatering takes about one hour so fifteen hours of effective mining are completed each day.

A tin shed is operated by contractors.

Operating costs for this Mine are approximately \$25,000/month; Average monthly production of 4.2 tonnes of cassiterite from 30,400 m^3 of alluvial material with average grade of 0.17 (0.29) kg/m^3. Operating cost 82¢/m^3 (63¢/yd^3). The Operations Manager commented that the operating costs of this Mine were close to the average for deposits and mines of this size. The breakdown of costs is as follows:-

Power diesel and lubricants	\$10,400
Labour	\$ 4,200
Supplies (spares, etc)	\$16,700
Supervision and Management	\$ 3,000

Plate 4

Serem Malaysia - Sungkai Section
General view of pit.

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Plate 5

Serem Malaysia - Sungkai Section
Mining using 4 monitors, operator on right indicates scale.
Black shale basement.

Plate 6

Serem Malaysia - Sungkai Section
Cassiterite bearing alluvials, 3 M below surface.

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Plate 7

Serem Malaysia - Sungkai Section
Distributor from revolving screen
to palong

Plate 8

Serem Malaysia - Sungkai
Section. Palong.
Thatched sheds house
gravel pumps.

Plate 9

Serem Malaysia - Sungkai
Section. Palong.
Shed on left houses
clean up jigs.

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GOPENG CONSOLIDATED

The Gopeng Consolidated Mine is reputed to be the largest open cut alluvial tin mine in the world. Active mining has been carried out here for 90 years. The Company holds title to 5,000 acres.

The average depth of alluvials is 25 metres with a limestone bottom that is very irregular. Significant reserves exist under old tailings. These reserves were left by earlier mining operations that did not work ground deeper than about 10 metres. Rich alluvial tin is developed on the bottom in pockets between the limestone pinnacles but cassiterite is also developed throughout the virgin alluvial section.

The Mine is operated with ten sections. Each encompasses about 60 acres and has a life of three years. The life of each section also corresponds to the life of a wooden palong. Each section has a separate treatment plant. The Mine is entirely electrical.

Two mining methods are utilised:

- hydraulic mining with gravel pump and monitor
- dry mining with heavy earth moving equipment.

Dry mining is cheaper and gives a higher monthly yardage.

Hydraulic Mining

The first level operation carried out either with monitor/gravel pump or by mechanical stripping removes the 27m thick upper section of barren alluvials or tailings down to the top of the limestone pinnacles. This first level operation is often carried out mechanically using drag line/back hoe/truck on contract at a cost of 22-45¢/bank m^3. Drag lines are the most efficient method of removing material. The first level operation is followed by "pocketing". Pocketing involves locating a gravel pump in the deepest part of a limestone sink hole and using one or more monitors.

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Pocketing is a slow operation but worthwhile because very high grades of cassiterite usually occur in the pockets. Automatic monitors are used throughout. These were developed by Osborne and Chapel, it appears that at Pioneer we have the Mark One model of the Osborne and Chapel automatic gravel monitor which was never terribly successful. The Mark Two model currently used at Gopeng Consolidated is highly successful. They claimed that automatic monitors give 50% greater cutting efficiency than manually operated monitors and are safer as you don't lose an operator when the face collapses. The following gravel pumps are used:

1st Level	:	300 horsepower, 27 metre head
Pocketing	:	200 horsepower, 8 metre head

The budgeted production for each hydraulic mining section is 61,000 m^3/month. Material is treated by trommel/palong/jigs.

Dry Mining

I inspected one of the dry mining operations, Gopeng South. On average 91,000 m^3/month is mined. This section has a three year production life. All mining is by mechanical methods utilising:

1.14 m^3 draglines, 0.76 m^3 backhoes, 3.42 m^3 front end loader, 7 m^3 trucks.

All mining is done by contract for 23-45¢/bank m^3. The Volvo Front End Loader is the most efficient machine but is no good in wet weather. During the rainy season drag lines are used. Heavy equipment operators who usually own their own equipment are paid $125/month.

Dry mining is limited to a depth of about 12 metres, below which the cost of drainage.and mining is too costly to be feasible. Experience at Gopeng has shown that monitor stripping is more expensive than dry/mechanical stripping.

At this section, the alluvials consisted of clayey sand and sandy clay with tin distributed evenly throughout the section. Average grade was 0.23 (0.39) kg/m^3. Initial boring to delineate reserves was carried out on an 80 metre grid with a hand bangka drill. As mining progresses 6cm diameter power auger drilling on a 20 m grid to a depth of 3.5 metres is carried out on the mining benches. This close spaced auger drilling is found to give only 50% of the grade recovered in production and is thought to be due to the small diameter of the drill.

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017 The tin bearing alluvials are carried from the mine site to a dump nearby in 7 m^3 trucks. The treatement plant is as follows:-

Dump - 3 monitors - 300 horsepower gravel pump - trommel - desliming tank (considerable clay in alluvials) - distribution box - 20 lane palong 2 or 3 of the lanes of the palong are continually being cleaned up. Material from the clean up is pumped to 6 x 2 cell primary jigs, in parallel, 1 x 1 cell secondary jig, 1 x 1 m cell. Reject from the primary jig is recirculated over the palong. The jig produces a 30% cassiterite concentrate.

The tin shed handles concentrate as follows:-

Concentrate bin - sump - jigs - shaker tables - dryer - magnetic separators - high tension separators.

155 tonnes of cassiterite are produced a month and small amounts of monazite, ilmenite and zircon. These three accessory minerals are also sold but the revenue from them is not great.

Evaluation

Drilling - an 80 metre grid is generally used and drilling is carried out on contract by a hand bangka drill. A drilling crew consists of a 10 man gang who carry out drilling, washing of the alluvials to produce a cassiterite concentrate which is dried and weighed by the contractor. The standard cost for contract drilling is $84/day. Daily production rates are 8 metres in sandy wash, but for bouldery ground or alluvial containing stiff clay only a few metres per day are achieved. The bangka drill consists of 10 cm diameter casing, up to 30 m per day is achieved for drilling at Gopeng Consolidated.

Grade calculation of bore hole samples is based entirely on volume recovered. Drilling samples are placed in a calibrated box, they are not compacted, and the boxes calibrated to theoretical pipe volume, to allow 33% swell factor for dry samples and 50% swell factor for wet samples. Grades are corrected to theatrical volume. If the recovered volume is less than the theoretical volume, the grade is increased proportionally and decreased if vice versa. They do not use a Radford Factor. This method of grade calculation is considered to be very reliable.

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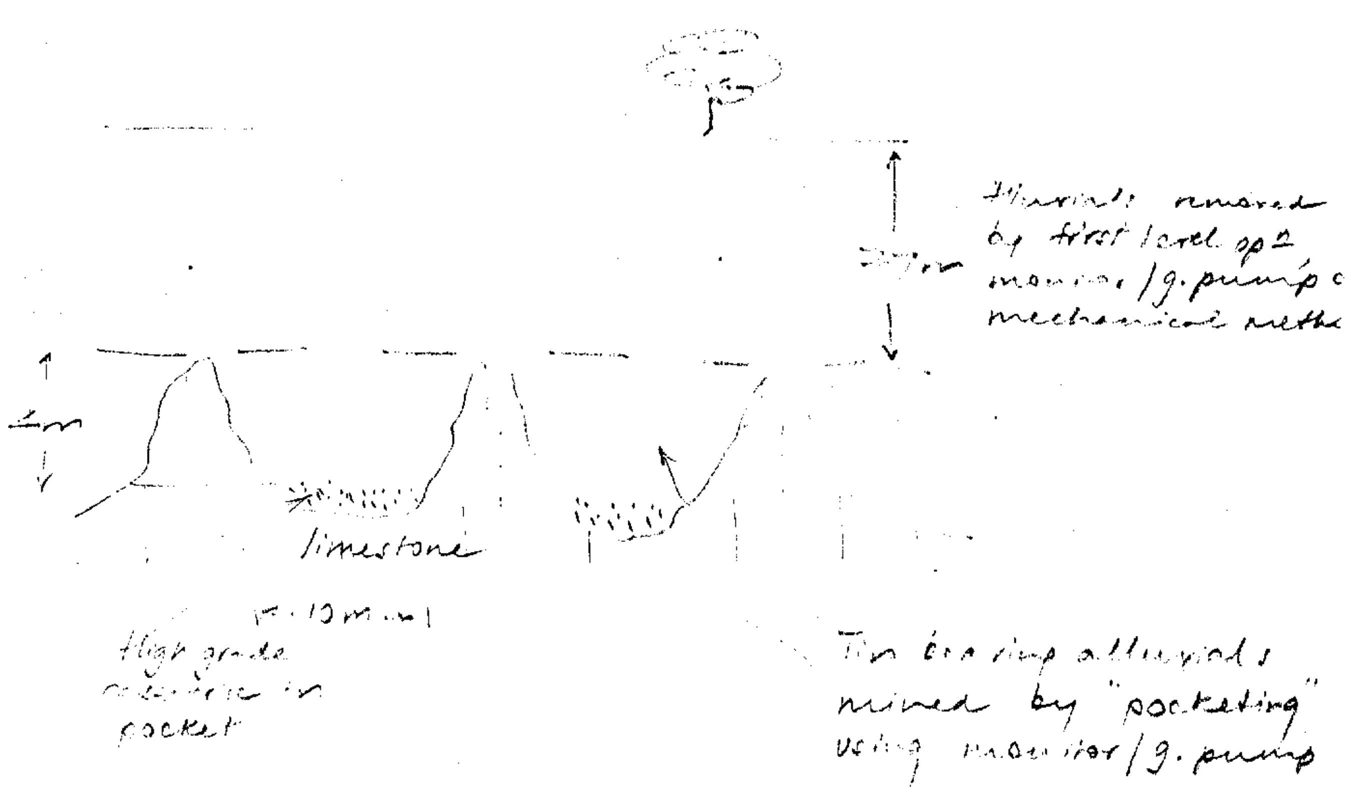
It appears that Gopeng Consolidated have never attempted to relate Bangka drill grades to production grades. Mining each month usually encompasses ground with grades delineated by 1 or 2 bore holes. It is thought at Gopeng that hand Bangka drilling grades are 90% of actual contained cassiterite.

Reserve Calculations - Horizontal method. 1.5 metre benches are used for the calculations. Area and grade are calculated for each hole for each 1.5 metre bench using the standard polygonal method. No cassiterite grain size cut-off is applied although it is considered that minus 200 mesh cassiterite is generally not recovered. Any single sample that assays greater than 0.77 (1.3) kg/m^3 is ignored. Any such high values are assigned a value which is the average of the two intervals above and two intervals below the sample in question. Reserve calculations use a cut-off of 0.12 (0.2) kg/m^3 for individual 1.5 metre benches. A batter of 1.5 to 1 is also taken into account when calculating reserves.

Grades currently being mined are as follows:-

Hydraulic mining 0.27 (0.46) kg/m^3
Dry mining 0.23 (0.39) kg/m^3



Hydraulic mining - schematic diag.

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KUALA LUMPUR

SUNGEI BESI

Located a few kilometres south of Kuala Lumpur this is the world's deepest open pit tin mine.

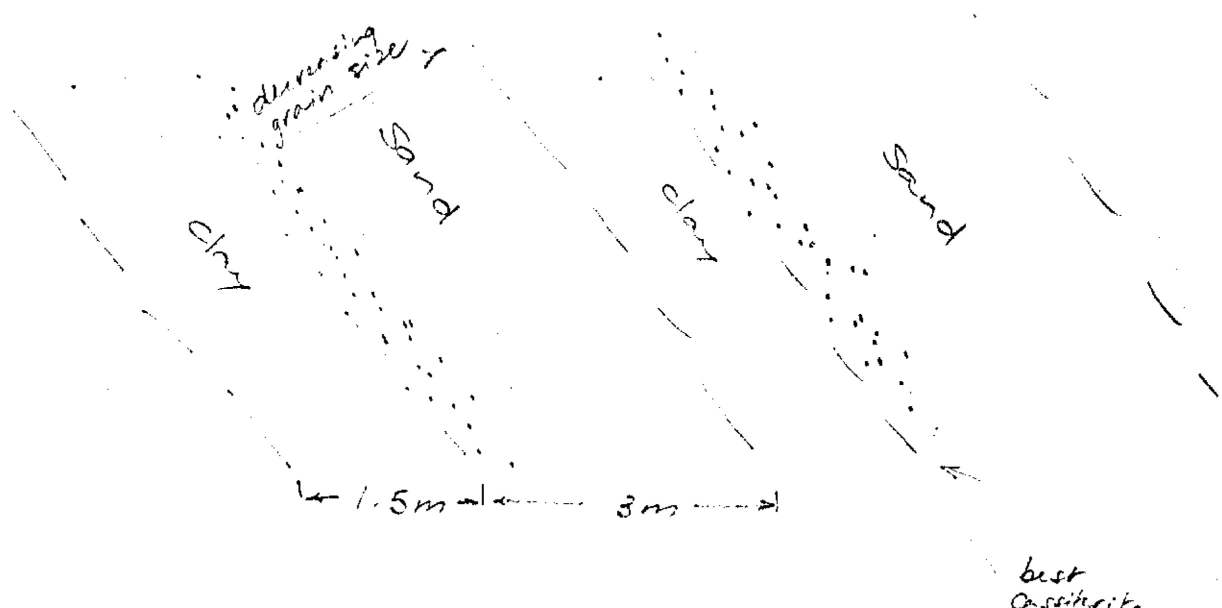
The deposit was first worked in the 13th Century by Thais. In 1909 it was reopened by English interests and worked up to World War II. In 1969 the Charter Consolidated group obtained title to the deposit and initiated re-evaluation and redevelopment. In 1975, the operation was incorporated into the newly reconstituted Pernas Charter Management group.

The mine is divided into three separate pits. Cassiterite is located in Quarternary alluvium contained within cast topography on a granite limestone contact.

Currently two pits (the Hong Fatt and 3/5 Complex) are being mined:-

Hong Fatt

Mining began at a depth of 114 metres below the surface and it is planned to mine to a maximum depth of 146 metres. Drilling has shown that cassiterite bearing alluvials extend to a depth of 185 metres below the local surface. The sequence at one point in the pit consisted of interbedded clay and sand with the altitude of 45^{o} that is thought to be due to slumping of the alluvial sequence over limestone sink holes. The strike of the sequence is parallel to the limestone/granite contact. Best tin is developed at the base of each sand layer.



Hong Fatt, pit exposure
Interbedded sand + clay at 45°
Best [illegible] developed with
coarse sand at bottom of sand
layer

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Plate 10

Sungei Besi
General view, Hong Fatt open pit;
the world's deepest open cut alluvial
tin mine.

Plate 11

General view 3/5
complex

Plate 12

Thatched pit walls,
to prevent erosion,
3/5 complex

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Pit slope on alluvium is 28°. Pit walls are thatched to prevent erosion during heavy rainstorms. Pit slope on limestone is 45°. Gradient of roads within the pit is 1:10.

Pit dewatering is carried out by four 270 hp gravel pumps and four 750 hp water pumps with a capacity of 3,000 gallons/minute. These pumps are in series.

Mining is carried out on contract using 0.76 and 0.95 m^3 backhoes, 3.1 and 4.6 m^3 trucks and Cat 977K track-driven front end loaders. Mining costs vary from 60¢ to \$1.10 yd^3 depending on haul distance and road conditions. Where possible, mining is selective and the relatively barren clay is discarded. 42,000 m^3/month are mined.

3/5 Complex Pit

Similar operation to Hong Fatt. 95,000m^3/month mined, half of which is barren and discarded. Average grade is 0.23 (0.4) kg/m^3 using a 0.12 (0.2) kg/m^3 cut off. Grain size of the cassiterite is -70 to +100 mesh.

The plant employs 10 persons and has a capacity of 182 m^3/hr. Treatment is as follows:-

> Stockpile - bucket wall - trommels with 1 and 30 cm screens, + 1 - 30 cm scrubbed, + 30 cm dumped - sump - desliming - cyclone to remove -300 mesh - 16 x 4 cell step jigs, cell 1.2 x 1.2 m cells x 2 x 3 cell secondary jigs, 1.2 x 1.2 cells - 1 x 2 cell tertiary jig.
>
> The tertiary jig concentrate assays approximately 50% cassiterite. Primary jigs are continuously sampled and the sample material can be run over a quarter-sized table. Plant recovery of 99% is maintained and if recovery falls below this level the plant is considered not to be working correctly.

The tin dressing shed employs 26 persons. Monthly production is 180 tonnes of cassiterite.

An extract from the annual report for the period ending 31 March 1978 is attached in Appendix 1.

AYER HITAM

The Ayer Hitam alluvial tin dredging operation is located south of Kuala Lumpur. It is managed by the Pernas Charter Consolidated group. Three dredges are active at this mine.

The dredges are mining both virgin tin bearing alluvials and areas which have been previously dredged. The cassiterite seems to be distributed throughout the alluvial section and varies in grain size from -100 to +150 mesh. The bottom is limestone and naturally is very irregular. A good correlation has been established between recovered cassiterite and drill-indicated grades. Past dredging statistics allow the relationship to be established and although figures were not given it is apparent that drill indicated grades are approximately 70% recovered reserves.

Some of the alluvials currently being worked have been dredged twice before. In other areas prestripping to a depth of 9 metres is being carried out using 0.6 m^3 drag lines and 8 tonne trucks. The stripping is carried out on contract for a cost of 53¢/m^3 and approximately 38,000 m^3 per month is being stripped.

I inspected the No. 2 Dredge. This dredge holds the world record for the highest production of cassiterite for one month, 774 tonnes. No. 2 Dredge is the largest on the property and has a depth capacity of 51 metres, the dredge has 133 0.56 m^3 buckets and has approximate monthly production of 304,000 m^3. Mining costs of this dredge are 61¢/m^3, this cost includes all overheads. The dredge is entirely electric utilising power from the Malaysian National Grid at a cost of 5¢/unit. Replacement cost of the dredge is quoted to be $10 million.

Present monthly production at Ayer Hitam from the three dredges is 223 tonnes of cassiterite.

Engineers I spoke to on site indicated that Ayer Hitam is a very complicated property to operate because of the highly erratic distribution of tin and constant variations in water level which affect the depth to which dredges can operate. Mine planning is maintained five years ahead.

Brief notes on Ayer Hitam Tin Dredging Limited are attached in Appendix 2.

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SYARIKAT TRIMAL

This gravel pump mine is located 6 km north of Kuala Lumpur and is owned and operated by a Chinese partnership. No specialised technical personnel are on site and the services of a consulting mining engineer are used from time to time.

This area was previously dredged twice to a maximum depth of 27 metres by Renong Tin.

Cassiterite appears to be distributed throughout the virgin alluvials but the highest grades of cassiterite occur in pockets on the limestone bottom between the limestone pinnacles. An inspection of the pit indicated that well-sorted wash consisting of clean quartz sand with subordinate sub-rounded pebbles up to 8cm contained obvious very coarse-grained cassiterite. Most of the cassiterite is probably +70 mesh in grain size. No reserve grades were given, the mine has a life of four to five years.

Stripping is being carried out on contract to a maximum depth of 27 metres. The stripping is being undertaken with $0.76m^3$ drag lines and 10 tonne Isuzu 10 wheel trucks for a cost of 40 ¢/bank m^3. Larger equipment is not used because of the soft and boggy nature of the tailings which are being stripped.

The mine is being operated in six sections, each of which consists of monitors, gravel pumps and a palong with jigs for concentration. The mining method is that of "pocketing" and in most cases, a gravel pump is located in a pocket or Karst depression in the irregular limestone bottom. Tin-bearing alluvials are moved to the gravel pump by monitors or in some cases backhoes or bulldozers are used to move alluvial material to a stockpile which is subsequently monitored to the gravel pump. This latter method is often used when the pockets are too small to justify moving a gravel pump into them. On one of the six operations that I inspected, a 620 horsepower diesel engine powered a 40 cm Malaysian gravel pump with a 32 m head.

Each of the six treatment plants is arranged as follows. A revolving screen or trommel - 10 lane palong - sump - gravel pump - 70 cm cyclone - 2 x 2 cell primary jigs, 1 x 1 m cell - 1 x 2 cell secondary jig, 1 x 1 m cell.

Operating costs were claimed to be $235,000/month but this figure is probably an understatement. The production quoted by personnel at the mine was far below that which I ascertained by making enquiries elsewhere. Actual

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Plate 13

Syarikat Trimal
General view of pit,
note limestone
pinnacles.

Plate 14

Syarikat Trimal
Backhoes and
bulldozer "pocketing"
between limestone
pinnacles.

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production appears to be between 120 and 170 tonnes of cassiterite a month. The mine employs 300 people including contractors.

The following equipment is being utilised:

3 draglines, RB 22, Model 30
10 bulldozers, Cat D6C, swamp tracks
5 backhoes
10 Isuzu 10 wheel 10 tonne trucks
6 gravel pumps
6 water pumps
6 x 12 lane palongs.

Plate 15

Syarikat Trimal
Cleaning up 3
lanes of a palong

Plate 16

Syarikat Trimal
Cleaning up
palong.

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INDONESIA

P.T. Koba Tin, Bangka Island

P.T. Koba Tin is a very large gravel pump mining operation owned by P.N. Timah (Indonesian Government) 25%, and C.S.R. - B.M.I. as Kajuara Mining, 75%.

The Islands of Bangka and Belitung form the South-Eastern extremity of the South-East Asian tin belt. Bangka is probably the richest alluvial tin area in the world. P.T. Koba hold an area 60 km long x 10 km wide which encompasses many mining leases.

Cretaceous granites (100 m.y.) intruded anticlines of Permean-Triassic metasediments and sediments. The granites are tin-bearing. Subsequently a regolith up to 80 m thick has formed consisting of incoherent material over bedrock including alluvium, eluvium and colluvium.

Definitions:

alluvium - material transported and deposited by a stream
colluvium - material transported essentially by gravity
eluvium - material formed in situ by decomposition of rock
kaksa - stanniferous placer directly on bedrock
mincan - perched placer neither on bedrock or at surface
kulit - near surface stanniferous placer.

Primary tin is confined to a 5 km zone straddling the granite sediment contact and occurs in greissens, pegmatites, veins or vein swarms.

The stanniferous placers being worked are proximal to the source. Tin is coarse grained, approximately 65 mesh, and generally in alluvials less than 20 m deep. The stanniferous alluvials are mainly on a fairly even, flat weathered granite bottom and many of the source areas in the granite lie directly beneath tin bearing alluvials. It is thought the stanniferous placers formed periodically in response to sea level changes. Depositional history was complicated with stanniferous placers being formed over at least the last 1 million years. There is no relationship between present topography and granite topography, in fact topographic inversions often occur. Old valley floors are sometimes masked by false bottom of ferrugenous sand or laterite. Kaksa and mincan are both associated with kulit and draped over modern interfluves. Grain size and grain shape indicates much tin in kaksa and mincan was formerly kulit which was deposited in valleys during periods of erosion when sea level dropped.

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The following depositional processes are thought to have taken place:

- kaksa formed immediately after a period of high stream velocity during valley incision when valley fill flushed out.
- mincan formed immediately after a period of high stream velocity but valley not fully flushed out/or during period of only slightly higher stream velocity.
- kulit formed by decomposition of tin bearing underlying granites. It could also be formed from infilling (kaksa/mincan) of older valley no longer in evidence.

It is thought that a concentrating mechanism was active after the initial regolith formation to produce the very high tin grades which are currently being worked.

The sequences are very strongly weathered and sedimentary structures are hard to see. Moderate stratification is evident with clay, sand and gravel lenses. The sequence generally coarsens downwards but is obviously highly variable with coarsest material about 10 cm diameter. Tin appears to be distributed throughout the sequence.

Koba Tin began exploration in December 1971 and mining started April 1974.

To December 1977, 12,000 holes were drilled by Koba for a total of 80,000 m on a true north grid. Mine blocks were drilled on a 10 x 20 m grid although the initial drilling was only 500 x 90 m grid. Significant amounts of earlier data was available from Dutch production and exploration drilling which had been going on during the previous 80 years. This data was quite reliable and certainly indicated the incredible size and high grade of the area. Koba were initially awarded a large Exploration Licence 60 km x 10 by the Indonesian Government but were forced to relinquish this progressively and now only hold leases. Clearly, tens of thousands of tonnes of cassiterite exist in the area dropped by Koba through their forced relinquishment. Most of the drilling is carried out by a hand bangka drill utilising a crew of 14. Sampling on a 1 m interval or change of ground, whichever is less. The volume is determined by puddling the clay, measuring the volume of sand in a calibrated bucket and determining the clay volume by assuming clay has SG = 2, and using the formula Vc=W-V.

Where Vc = volume of clay

W = weight of water + clay (kg)

V = volume of clay + water (l)

Details of this derivation and a copy of P.T. Koba Tin drill log is contained in the Appendix 3 and 4.

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The tin is dressed by hand and the cassiterite weighed. Mineralogy is carried out on selected samples; grain count, grain shape and size are determined.

Ore grade determinations are carried out as follows:

0 - 3 m related to theoretical pipe volume, this is necessary because the Bangka drill tends to undervalue near surface material.
+ 3 m related directly to recovered volume, grades quoted in Sn/m^3 assume 0.725 Sn = SnO_2.

Drag tin is often encountered at the bottom of holes and this amount is added to the last interval of alluvium. Reserve calculations are carried out using the standard polygonal method for whole of hole grades to give geological reserves which are sent to Mine Planning with a full geological report on lithology, grain size, mineralogy and cassiterite distribution. Variogram treatment of ore grades indicates east-west correlation is related to braided channels and meander wavelength. North-south correlation related to channel width. The paleodrainage generally trended north.

Published reserves from boring are thought to be 70-80% actual contained cassiterite reserves. Eleven reserve zones have been defined for a total of 66,190 tonnes of tin contained in 147,208,000 m^3 at a grade of 0.62 kg SnO_2/m^3. A cut off grade of 0.2 kg SnO_2/m^3 was used.

The relationship between recovered grade from mining and drill indicated reserve grade is not really known. Production is thought to be probably 100-110% of drill indicated grades but varies between 30 and 200% particularly in shallow ground where highly variable cassiterite makes it impossible to relate production to drill indicated grades.

Mining is presently being carried out at 13 different sites. There are 11 gravel pump mines and 2 small dredges. The mine employs 2,000 personnel, 24 of whom are expatriates and 15 Bangka drill crews are currently working. A gravel pump unit consists of 2 monitors, 2 x 30 cm gravel pumps in series, 1 bulldozer, 1 palong, primary and secondary jigs. Each unit produces 35,000 m^3/month. Bulldozer stripping is only considered economic to a depth of 7 m. Mining costs are $1.65/$m^3$ plus overheads.

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Plate 17

Koba Tin
General view, typical mining operation.
Stanniferous alluvials mined by bulldozer and pushed to gravel pump.
Monitor only used to "force feed" gravel pump.

Plate 18

Koba Tin
Bulldozer pushing ore to gravel pump.

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Plate 19

Koba Tin
Palong, lanes on right have been cleaned up.
Conical screen in background.

Plate 20

Koba Tin
Clean up plant adjacent to palong. Cyclones, primary jigs, secondary jigs and concentrate bins.

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Plate 21

Koba Tin
Bangka drill crew in action, standing on platform which has capstans for rotation.

Plate 22

Koba Tin
Final washing of drill sample with coconut shell to separate cassiterite from other heavy minerals.

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Mining is carried out the following way:

Stanniferous alluvium is moved by the bulldozer approximately 30 m from the face to the gravel pump where it is monitored into the gravel pump sump. No monitor mining is carried out. The gravel pumps are assumed to move approximately 60 m^3/hour and each operation is only worked 2 x 8 hour shifts. Alluvials are pumped to a conical screen, through a distributor and onto an 8-10 lane palong which is being continuously cleaned up one lane at a time. Clean up material passes through a 30 cm cyclone over 2 x 3 cell step jigs, each cell 1 x 1 m then to a single 2 cell secondary jig, 1 x 1 m. Average head grade for mining is 0.8 kg of SnO_2/m^3. Present production 300 tonnes/month. During the period April 1974 to December 1977 4,300 tonnes of tin metal (or 5931 tonnes cassiterite) were produced. Production is forwarded to Mentok Smelter near Pangkalpinang on Bangka Island. Dredges mine approximately 60 m^3/hour but I did not inspect these.

The tin shed consists of the following: sump - 4 x 2 cell jigs, 1 x 1 m cells - hydrosizer - 6 tables - drier - 4 electrostatic separators - 2 magnetic separators - 2 air tables. It is operated on a 3 shift basis and currently produces 300 tonnes of cassiterite/month.

The laboratory contains an XRF unit which has a capacity of 40-50 samples/day from the mine and drilling. Detection range 100 ppm - 40% Sn. Cost of each determination is \$6-7. Volumetric analyses are carried out for +50% Sn using iodine/HCl/sodium peroxide digestion, this method is used for determination of tin content of high grade concentrate for the smelter. Accuracy is ± 0.05% and capacity 10-15 samples/day.

Mining costs were difficult to rationalise. Total operating costs for 1978 were quoted to be \$3.58/m^3. The feasibility study assumed an operating cost of \$3.10/m^3. I was told mining costs were \$1.65/m^3 but the cost control report attached as Appendix 5 indicates mining costs for May 1979 for Operation West, which encompasses 6 of the 13 operating units, was 88¢/m^3.

COMPARATIVE SUMMARY - ALLUVIAL TIN MINES, S.E. ASIA TIN PROVINCE.

NAME/ LOCATION	TYPE OF OPERATION	MONTHLY PRODUCTION tonnes/tin	GEOLOGY	MINING METHOD	TREATMENT PLANT	PRODUCTION VALUE $/month	OPERATING COST $/month
Batu Gajah, Kinta Valley	4 dredges	78	Alluvials, tailings from previous Chinese mining and earlier dredging, limestone bottom Grade 0.036 - 0.083 kg/m^3	4 dredges, 1.08 million m^3/month Mining cost 32c/m^3 Largest dredge TT5, depth capacity 32 m, 349 000 m^3/month Head grade May 0.04 kg/m^3	Largest dredge 3.2 m, revolving screen, 48 primary jigs, 8 secondary jigs, all 2 cell 2 x 2 m	793,000	336,000
Ayer Hitam, south of Kuala Lumpur	3 dredges	221	Virgin alluvials, previously-dredged alluvials, cassiterite from -100 to +150 mesh throughout section, limestone bottom No grade given	Prestripping to 9 m, 0.62 c/m^3 Draglines, 8 tonne trucks, 53c/m^3, 38 000 m^3/month Monthly production 0.68 - 0.9 mm^3 Largest dredge No. 2, depth capacity 51 m, 304 000 m^3/month Mining cost 61c/m^3		2,200,000	1,000,000
Serem Malaysia, Sungkai	*Gravel pump*	4.2	Virgin alluvials, 6 m deep, cassiterite in lenses of wash throughout section, weathered black shale bottom, 7 years reserves, 450 tonnes contained cassiterite Grade 0.142 kg/m^3	4 monitors, 23 cm Malaysian gravel pump, 300 horsepower motor, 30 400 m^3/month Mining cost 83c/m^3	1.22 m revolving screen, 10 lane palong, 46 cm cyclone, 2 primary jigs, 1 secondary jig, all jigs 2 cell, 1.2 x 1.2 m cell	42,700	25,000
Gopeng Consolidated, Kinta Valley	Gravel pump and dry mining	155	Alluvials, mainly deeper alluvials below previously worked ground, depth 26 m, cassiterite mainly on bottom, but also through section, limestone bottom Current head grades: - hydraulic mining 0.27 kg/m^3 - dry mining 0.231 kg/m^3	Mine divided into 10 sections 2 mining methods: i) hydraulic in 2 steps, 1st level to top limestone pinnacles with automatic monitors and 300 h.p. g.p. 27 m head, pocketing between limestone pinnacles with 200 h.p. g.p. at 9 m head, 61 000 m^3/month ii) dry mining, 7 m^3 trucks, 1.1 m^3 drag lines, 0.76 m^3 backhoes, 3.4 m^3 Volvo front end loader 91 000 m^3/month each section, 22-45 c/m^3 Dry mining cheaper/m^3 than hydraulic	Hydraulic : screen-palong-jigs Dry mining : stockpile-3 monitor-gravel pump-screen-palong- 6 primary jigs, 2 cell, 1 x 1 m -1 secondary jig	1,575,000	Not given
Sungei Besi, south of Kuala Lumpur (World's deepest open cut tin mine)	Open pit and dry mining	180	Alluvials in solution cavities on granite/limestone contact, tin bearing alluvials to 184 m, cassiterite in coarse sand, cassiterite -70 +100 mesh, limestone or granite bottom Grades 0.81 - 1.85 kg/m^3	2 open pits, Hong Fatt at 130 m and 3/5 Complex at 107 m Similar mining methods in both pits, 0.95 m^3 backhoe, 3-4.6 m^3 trucks, Cat 977 K front end loader Some selective mining where barren clay developed, 137 000 m^3/monthly All mining by contract at 43-137c/m^3 depending on haul distance and mining depth Considerable stripping to maintain pit slope at 28%	180 m^3/hr capacity, stockpile-bucket wheel-trommel screen, 1 cm holes- +1 - 30 cm screen-scrubber -sump-cyclone-16 primary 4 cell step jigs at 1.2 x 1.2 m cell-2 secondary 3 cell jigs-1 tertiary 2 cell jig N.B. Primary jig overflow continuously sampled and put over ½ table, if recovery on primary < 99% consider plant not properly tuned	1,830,000	Not given
Syarikat Trimal, north of Kuala Lumpur	*Gravel pump*	7 120-170	Area already dredged 3 times to 27 m, virgin alluvials between 27-52 m. Best cassiterite in well sorted, clean quartz sand and quartz pebbles (≤ 9 cm) in bottom limestone pockets, cassiterite probably +70 mesh, limestone bottom, 4 to 5 years reserves Grades not known	11 gravel pump mines, 2 dredges Gravel pump mining, 6 separate operations Prestripping 27 m dredge tailings, 0.76 m^3 drag lines, 10 tonne trucks, 40c/bank m^3. Monitor-620 h.p. gravel pumps through 40 cm pipe-30 m head. Some gravel pumps fed by backhoe and bulldozer cleaning up pockets, metreage unknown	Trommel-palong-sump-gravel pump-70 cm cyclone-2 primary jigs, 2 cell, 1 x 1 m- 1 secondary jig, 2 cell, 1 x 1 m	1,200,000-1,700,000	315,000
Bangka Island, P.T. Koba Tin	11 discrete gravel pump operations 2 small dredges	300	Alluvials up to 80 m deep, 65 mesh cassiterite, cassiterite on bottom, near surface or perched higher grade zones. Undulating granite bottom Reserves 147 million m^3 at 0.62 kg SnO_2/m^3	Each gravel pump operation consists bulldozer, 2 monitors, 2 x 30 cm gravel pumps, 10 lane palong, primary and secondary jigs. Each unit produces 35 000 m^3/month with 0.6 kg/m^3 head grade. Mining cost $1.65/$m^3$ Total operating costs for 1978 $3.58/$m^3$		3,050,000	1,503,600

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DRILLING AND EVALUATION METHODS

Pernas Charter Management
Kuala Lumpur
M.K. Choo (Senior Geologist)

Grade determination from drilling by relating recovered volume to recovered tin.

Drilling Sample treatment

1. Recovered volume for 1.5m samples determined by weighing samples. They have determined from tests SG of alluvials in an area, say 1.8. Claim they can determine volume from weight.

2. Samples screened, 2 mm to determine clay/gravel content - also use comparators.

3. Both fractions washed up to tin concentrate.

4. Heavy mineral concentrate split
   - assayed at lab
   - point count.

   Usually little difference between lab and field determinations.

5. Screen tests on bulked samples, samples bulked according to grades, say 0 - 0.1, 0.1 - 0.2, 0.27 intervals.

6. Mineralogical tests also on selected samples.

See Walker, 1974, paper on drilling, 4th World Conference on tin.

Pernas never discount high grade samples or fiddle assay values for individual intervals.

Borehole spacing, 10cm mechanical bangka drill

- dredging property, 160 m, ground considered fairly homogeneous
- dry mining e.g. Sungei Besi, 30 m square grid oriented along strike of limestone/granite contact
- detailed pit drilling, auger, 5 cm, 5 m grid, gives only semi-quantitative data, fast and really only distinguishes wash/ore.

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Drilling recoveries

Found that in bouldery ground > diameter sand pump, recovery often only 20% theoretical volume, in bouldery ground usually assume 65% recovered volume so effectively undervalue ground.

Cf. of pitting and boring bouldery ground, drilling grades determined from actual volumes up to 10 times pit grades.

Evaluation

2 methods - area of influence, blocks defined by mid points between holes
- homogeneous block method.

Latter more accurate.

Homogeneous block method

Isolate blocks based on similar geology and metallurgical characteristics.

Plot
- tin value contours for whole section
- stanniferous sediment isopach
- total sediment isopach
- bedrock contour
- cross-sections with geology and tin grades.

Plans and sections studied to define homogeneous blocks.

Geological reserves calculated for homogeneous blocks on benches, say 15' for Sungei Besi, used a 0.16 (0.27) kg/m^3 cut off.

Recoverable reserves then calculated by applying empirical recovery factor based on
- clay content
- mineral assemblage
- grain size.

Recoverable reserves usually 80-90% geological reserves.

Both types of reserves calculated for individual ore blocks and bulk grades.

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APPENDICES

1. Sungei Besi, extract from annual report.

2. Brief notes on Ayer Hitam.

3. Koba Tin drill log.

4. Koba Tin, drill sample volume determination.

5. Koba Tin, cost control report, May, 1979.

The Sungei Besi Mines Berhad
Report and Accounts for 15 mths period ended 31 March '78

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The Sungei Besi Mines Malaysia Berhad

Report by the general managers

Pernas Charter Management Sdn. Berhad, who were appointed general managers of the Company with effect from 1 January 1978 in place of Associated Mines (M) Sdn. Berhad, submit their report on the work carried out on the property of The Sungei Besi Mines Limited during the year ended 31 March 1978.

Production statistics, compared with those of the previous year, are as follows:

Ore mined and treated		1977/78 Cubic yards	1976/77 Cubic yards
No. 2 Opencast		1,527,400	1,461,000
No. 3/5 Opencast		274,500	831,700
No. 5 Opencast		61,300	179,000
Total ore mined and treated (a)		1,863,200	2,471,700
Total ore stockpile at 31.3.78	77,800		
Less ore stockpile at 31.3.77	58,200		
		19,600	7,100
Waste mined and dumped (b)		1,696,200	2,478,900
Total cubic yards mined		3,579,000	4,957,700

Note: 62,700 cubic yards of ore-in-waste *moved to producing units for treatment have* been included in (a) and excluded from (b).

Production	1977/78 Piculs	1977/78 Tonnes	1976/77 Piculs	1976/77 Tonnes
No. 2 Opencast (average value 1.61 kpcy)	24,631	1,490	12,356	74[illegible]
No. 3/5 Opencast (average value 2.35 kpcy)	6,440	389	11,512	69[illegible]
No. 5 Opencast (average value 1.02 kpcy)	624	38	874	5[illegible]
	31,695	1,917	24,742	1,49[illegible]

	1977/78	1976/77
Average assay %	72.32	73.12
Total mining costs ($ million)	15.69	17.97
Cost per cubic yard treated ($)	8.42	7.27
Cost per cubic yard mined ($)	4.38	3.63
Average cost per picul ($)	495	726
Average price realised per picul ($)	818	642

NO. 1 OPENCAST
Tribute mining by gravel pump/palong continued satisfactorily on the low grade tailings dump at the north-eastern edge of the opencast.

NO. 2 OPENCAST
This opencast was again the main area of activity of the mine and its three producing sections contributed the bulk of the company's overall production.

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Eastern Slopes and Western Slopes
Operations at the Western Slopes continued with contract excavation/haulage of the ore to the Barrier's palong/jig plant for treatment and recovery. A favourable throughput was attained but production was low because of low grade reserves being mined. Treatment of the small stockpile of low grade primary ore from the Eastern Slopes continued at the Lode Plant and yielded satisfactory production.

Hong Fatt
Methods of removing the wet slime were successfully developed and excellent progress was maintained with the deepening of the main pit which reached the −240' level at the end of the financial year. Large quantities of low grade ore-in-waste continued to occur but good production was achieved on account of high throughput.

The rate of removal of limestone from the southern slopes of the pit was increased to facilitate access to the alluvium below. Drainage, dewatering and slope stabilisation was given careful attention to ensure that the safety and continuity of operations was not affected.

NO. 3/5 OPENCAST
There was limited mining of the shallow reserves at the north-east flank of the northern section where little development was required. Production was favourable.

At the southern section operations were confined to small scale selective mining of remnant high grade alluvial and primary ore.

NO. 5 OPENCAST
The gravel pump unit at Hong Fatt Extension performed satisfactorily treating low grade materials brought in from other sections of the mine.

MAIN TREATMENT PLANT
The plant operated satisfactorily throughout the year, although at a reduced throughput because of the gradual scaling-down of mine operations.

MINING TITLES
Of the 2,274 acres in Selangor and the Federal territory held under mining title by the company, titles over 2,053 acres had expired by 31 March 1978. Renewal applications were submitted in the normal way and in good time but these applications have been neither granted nor refused. Although some of the expired leases are over areas of current working, mining operations were not affected.

Tin price
The average net price received per picul of tin concentrate sold, after deducting tribute paid, was $818 (£3,080 per tonne), the average gross Penang tin price for the year being $1,626 per picul (£6,123 per tonne).

Tin duty and surcharge
Tin export duty and tin export surcharge totalling $10,749,186 were paid to the Malaysian Government on 31,669 piculs of tin concentrate sold, equivalent to $339 per picul (£1,276 per tonne) of tin concentrate.

General
Relations with the employees' unions remained cordial. Rainfall at No. 2 Opencast was 90.30 inches and at No. 3/5 Opencast 81.78 inches.

Staff
Our thanks and appreciation are due to the mine manager and all employees for their loyal assistance throughout the year.

Pernas Charter Management Sdn. Berhad
C.J. FORRISTAL
General Manager

Kuala Lumpur,
Malaysia
5 June 1978

Note

1 kati	= 1 ⅓ lbs
100 katis	= 1 picul
1 picul	= 133 ⅓ lbs
16.53 piculs	= 1 tonne
M$4.39 in 1978	= £1
M$4.27 in 1977	= £1

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Brief Notes on Ayer Hitam Tin Dredging Limited

Puchong, Selangor

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AYER HITAM TIN DREDGING LIMITED

1. INTRODUCTION

Ayer Hitam Tin Dredging is located in the Puchong valley approximately 14 miles south-south-west of Kuala Lumpur, the capital of Malaysia.

The Company operates three bucket dredges on mining leases totalling 2,035 acres, producing tin in concentrate form.

2. HISTORY

The Company was incorporated in the U.K. in 1926 and began operations in its present leases in 1929 with its No. 1 Dredge. In the 1950's the Company purchased a gold dredge from Harrietville, Australia, and reconstructed it in Malaysia as the No. 2 Dredge. In 1965 the Company expanded its operations further with the purchase of the Hong Kong Tin steam-driven dredge, and had it modernised, electrified, and refitted as the No. 3 Dredge.

3. GEOLOGY

The stratigraphy at Ayer Hitam is as follows:–

Limestones	(Lower Palaeozoic)
Schists (with minor intercalations of limestone & shale)	(Permo-Carboniferous)
Granite	(Mesozoic)
Superficial sediments	(Quaternary)

The granite intruded into the earlier sedimentary rocks during the Mesozoic Age. Primary tin mineralisation is related to the granite.

The limestone was subsequently peneplaned when the Quaternary seas transgressed the land. Sediments derived from the weathered granite were transported in a fluviatile environment down the granite slopes to the lower limestone platforms. Cassiterite ($Sn\ O_2$), because of its high specific gravity, became concentrated in geomorphological lows – solution cavities in the limestone and along the limestone granite contacts.

The coarse grained cassiterite-bearing sediments are overlain by stratified sediments with minor cassiterite concentration, barren, pale grey clay, and finally by carboniferous alluvium. The alluvium is generally about 100 ft thick, but localised deposits exist with depths as much as 300 ft.

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4. MINING

4.1 Pre-stripping

Pre-stripping is carried out ahead of all 3 dredges using front-end loaders, draglines and 5–8 ton tipper lorries. The work is normally done on a contract basis. Current excavation rate is roughly 200,000 cubic yards per month.

Developed initially for the No. 2 Dredge, the pre-stripping technique, coupled with a lowering of the dredge paddock water level, has enabled the dredge to exploit rich reserves up to 70 ft below its maximum digging capability (which at 167 ft already makes it the world's deepest digging bucket dredge).

Pre-stripping has been extended to Nos. 1 and 3 Dredges for the removal of the top layer of carboniferous alluvium. The carboniferous alluvium disintegrates on excavation giving rise to "corky wood" – jungle trash which floats at or just beneath the surface of the paddock – which causes blockages to the dredge pumps, particularly at the intakes. This technique, pioneered at Ayer Hitam, is now being adopted by an increasing number of dredge operators.

4.2 Dredging

The Company employs three medium capacity bucket dredges having throughputs in the order of 300,000 – 400,000 cubic yards per month in its mining operations.

Barren overburden, if any remains after pre-stripping, is stripped by the dredge to expose the cassiterite-bearing gravels. The stripped material bypasses the dredge treatment plant.

Excavated cassiterite-bearing ground is discharged into revolving screen(s) and is broken up by a combination of the tumbling action of the screen and high pressure sparge water.

The undersize (–3/8 in) material is concentrated by a three-stage jigging process. Primary jig tailings are discarded as waste behind the dredge while secondary and tertiary jig tailings are re-circulated. The tertiary hutch product forming the upgraded dredge concentrate is placed in tin ore bins for transfer to the tinshed. The grade of ore shipped from the dredge currently averages around 20% cassiterite.

5. TINSHED

The dredge concentrate is further upgraded in the tinshed to 96% – 98% SnO_2 (75% – 77% Sn) by the removal of associated gangue minerals present viz. quartz, pyrite, arsenopyrite, siderite, ilmenite, monazite and zircon.

The tinshed feed is basically sorted in a Willoughby classifier to separate the cassiterite into two fractions with the split at approximately 52 mesh BSS.

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The main gangue minerals in the coarse fraction are quartz, siderite, pyrite and arsenopyrite. Quartz and siderite are rejected as table tailings while the pyrite and arsenopyrite are removed by skin flotation on flotation tables.

The quartz, siderite, pyrite and arsenopyrite impurities are similarly removed from the fine fraction. However, the other main gangue minerals in the fine fraction, ilmenite, together with smaller quantities of monazite and zircon forming a table middling product require other means of removal. Ilmenite is removed by high intensity magnetic separators while zircon and monazite are removed using high tension separators.

The final concentrate is dried, bagged and shipped to Penang for smelting.

6. PRODUCTION

Mine production varies from year to year. Outputs during 1975/1976 and 1976/1977 were at record levels of around 70,000 piculs (4,200 tonnes) of concentrate annually, equivalent to 3,200 tonnes tin metal.

In November 1976, the No. 2 Dredge produced 13,249 piculs (801 tonnes) of concentrate, equivalent to 615 tonnes metal, the highest monthly production ever recorded by a tin dredge.

7. ANCILLARY SERVICES

The Mine has its own Planning Section which looks after planning, surveying and slope stability work.

The Mine is also equipped with a comprehensive workshop capable of fabricating and refurbishing worn dredge parts. The workshop also looks after the maintenance of the Company's earthmoving equipment and transport vehicles.

8. MANAGEMENT

Control of the Company was transferred to Malaysia in 1976. The Company is now part of the Malaysia Mining Corporation Group whose shareholders are Pernas, the national corporation of Malaysia, and Charter Consolidated Ltd. General management services to the Company are provided by Pernas Charter Management.

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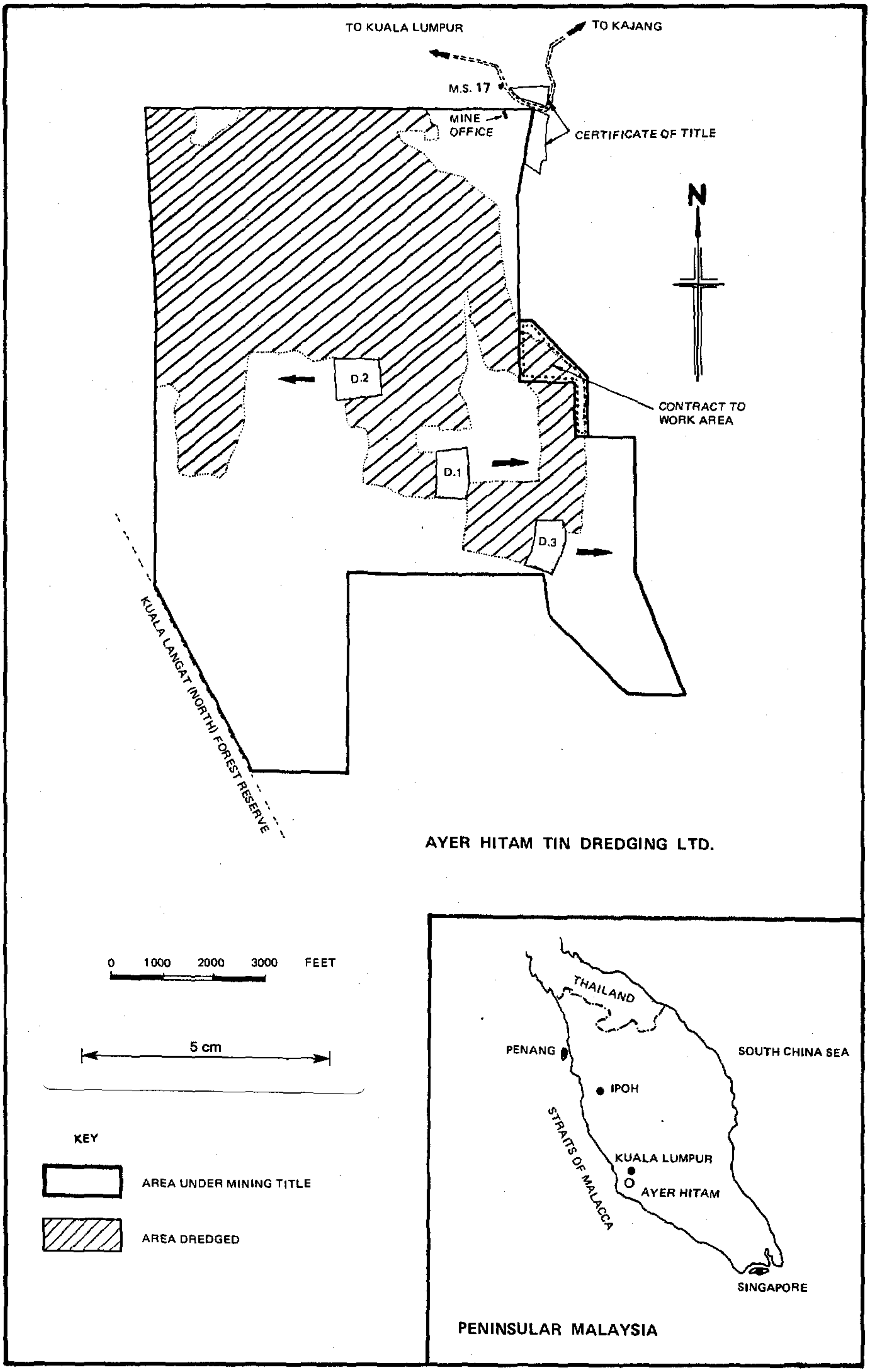
AYER HITAM TIN DREDGING LIMITED

DREDGE DATA

		No. 1 Dredge	No. 2 Dredge	No. 3 Dredge
First built		1929	1941	1929
Last re-built		1961	1958	1967
Pontoon length	(ft)	278	374	279
Pontoon width	(ft)	60	72	59
Bucket capacity	(cu ft)	14	20	14
Bucket speed	(per min)	26	22	26
No. of buckets		133	133	136
Digging depth	(ft)	125	167	125
Revolving screen				
Number		1	2	1
Diameter	(ft)	9	8	9
Length	(ft)	48	53	48
Speed	(rpm)	9	9	9
Jigs (Yubas)				
Primary		32 x 3 cell	48 x 3 cell	40 x 3 cell
Secondary		4 x 3 cell	6 x 4 cell	4 x 3 cell 2 x 4 cell
Tertiary		2 x 2 cell	2 x 2 cell	2 x 2 cell
Dredge capacity (cu yd/month)		320,000	440,000	340,000
Total installed horsepower		3,591	4,224	3,309

044


TO KUALA LUMPUR
TO KAJANG
M.S. 17
MINE OFFICE
CERTIFICATE OF TITLE
N
D.2
CONTRACT TO WORK AREA
D.1
D.3
KUALA LANGAT (NORTH) FOREST RESERVE
AYER HITAM TIN DREDGING LTD.
0 1000 2000 3000 FEET
5 cm
KEY
AREA UNDER MINING TITLE
AREA DREDGED
THAILAND
PENANG
SOUTH CHINA SEA
IPOH
STRAITS OF MALACCA
KUALA LUMPUR
AYER HITAM
SINGAPORE
PENINSULAR MALAYSIA

F.T. Koba Tin

Standard Procedures handbook

3.6.79

VOLUME DETERMINATION OF DRILL SAMPLES

Volume approximately equal to the volume of the clay itself.

From field observations it is considered that this method overestimates the amount of clay in the sample and hence leads to a slight underevaluation of the ground.

Volume of clay in slimes (elaboration).

Weight clay + weight water = Total weight but density = $\frac{\text{weight}}{\text{volume}}$ or weight = density x volume so vol. clay x S.G. clay + V water x S.G. water = Total weight.

$$V_c \times S.G._c + V_w \times 1 = W$$

$$\text{i.e. } V_c = \frac{W - V_w}{S.G._c} \qquad (1)$$

now Volume clay + Volume water = Total volume

so V_w = Total volume $- V_c$

$$= V - V_c$$

Therefore (1) becomes $V_c = \dfrac{W - (V - V_c)}{S.G._c}$

i.e. $S.G._c \times V_c = W - V + V_c$

or $V_c\,(S.G._c - 1) = W - V$

now if S.G. Clay taken as 2

$$V_c \quad (2 - 1) = W - V$$

i.e $\underline{V_c \qquad = W - V}$

/....

P.T. Koba Tin . Page 2.

COST CONTROL REPORT

148047

046

COST CENTRE : OPERATION WEST   MONTH : MAY 1979

6 MINING UNITS

	THIS MONTH			YEAR TO DATE	
	ACTUAL $	BUDGET $	VARIANCE $	ACTUAL $	VARIANCE $
1 Labour - Normal	28 389	39 900	+ 11.511	116768	+ 77.732
2 Labour - Overtime	17 473	29 800	+ 12.327	62874	+ 82.326
3 Contract Labour	2.317	7.200	+ 4.883	27571	+ 7.029
4 Stores *	93 237	66.900	- 26.337	258 500	+ 59.500
5 Fuel	59026	60.200	+ 1.174	230 832	+ 64.068
6 Contracts-Other *	55.422	14.600	- 40.822	126 692	- 58 192
7 Contract-Earth-moving *	80.607	55.000	- 25 607	194098	+ 58.402
8 Compensation	16 878	31500	+ 14 622	39 953	+ 137 247
TOTAL COST	353 349	305.100	- 48 249	1057288	+ 428 112
	165 667	96.000	- 69.667	281 342	+ 159 658
	187 682	209.100	+ 21 418	775 946	+ 268454

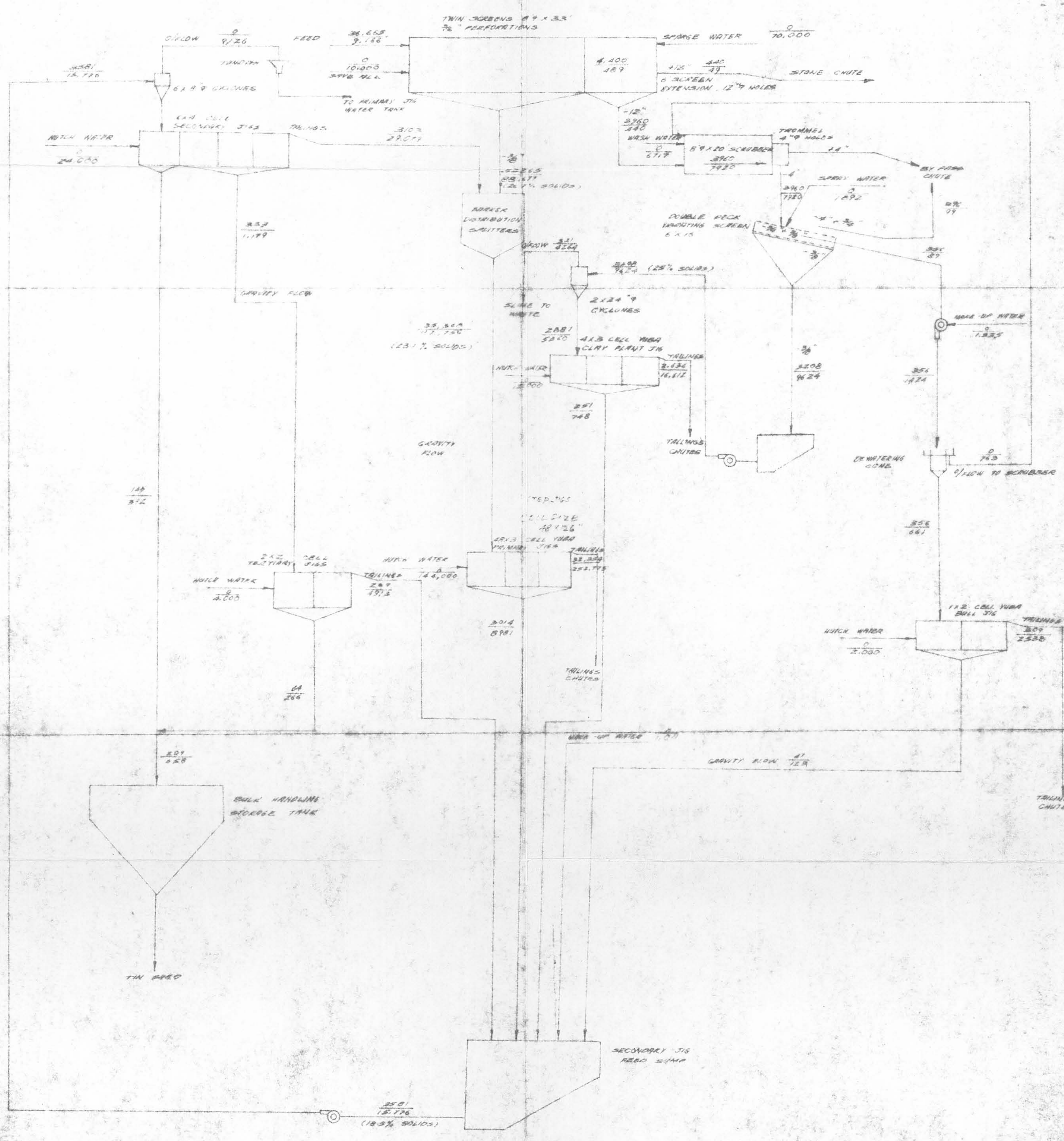
P.T. Koba Tin Manning	413	412	- 1	413	- 1
Overtime%	62	75	+ 13	54	+ 21
Contract Labour	1353	2793	+ 1440	16105	- 2685
M3 mined /000'S	213	256	- 43	1094	- 186
Total Cost/M3	0.88	0.82	- 0.06	0.71	+ 0.45
Tonnes Sn	108	135	- 27	589	- 86
Total Cost/tonne	1737.80	1548.89	- 188.91	1317.40	+ 883.19

EXPLANATION OF VARIANCES :

SUPERVISOR/MANAGER ....

NTS/nl

048



148048

ASSOCIATED MINES (M) SDN. BHD.

AYER HITAM TIN DREDGING LTD.

No.2 DREDGE

TREATMENT PLANT FLOW-SHEET

DRAWN BY	CHECKED BY
PLAN REF No. 05/1025(2)/2-75	DATE: 13th OCT. 1975

79-1373

148049

P.T. KOBA TIN

METHOD D

KOBA
BANGKA

047

AREA : JONG KONG.
SHEET REF : A - 9
Bore : JG: 8360/62A
Rl. Collar : 13.1
Rl. Kong : -
Bore Location : SECTION 8360

Commenced Time : 9.30 hrs. Date : 31 - 7 - 78
Completed Time : 13.30 hrs. Date : 31 - 7 - 78
Drilling Time : 3.30 hrs.
Drilling Rate : 1.3 m/hr.
Rig Type : BANGKA RIG.
Ground Water Level

Gang : D C: VIII.
Boring Clerk : KM AN AR .S
Dulanger : TAMSYIR .B
Ø : 120 mm
Th. Vol. : 10.9
Geologist :

CALCULATED BY : Faryono.
Date : 20-12-1978.
CHECKED BY :
Date :

Sample Number	Interval	Thickness (metres)	DESCRIPTION OF GROUND type	colour	% sand fraction G	VC	C	M	F	% Clay	Tenacity	Th. Volume (litres)	Kepalus Comments	Recovered Volume (litres)	Total Weight (kilograms)	Sand Volume (litres)	Volume % Clay Calculated	+ 4 Mesh	CASSITERITE CONCENTRATE Weight (grams)	Grade (kg/m3)	Richness (Thickness × Grade)	Cum. Richness	Cum. Grade (kg/m3)
1.	0.0 - 0.6	0.6	CLAY	MILKY	-	5	5	20	70	80	S	6.6		5.5	6.8	1.1	80	-	TR				
2.	0.6 - 1.5	0.9	SOFT CLAY.	BLACK	-	-	-	20	80	85	L	9.8		6.3	11.9	1.	84	-	0.2	0.02	0.02		
3.	1.5 - 2.0	0.5	SANDY CLAY	GREY	-	-	-	30	70	60	M	5.5		5.9	11.4	2.4	59	-	0.2	0.04	0.02		
4.	2.0 - 2.5	0.5	SANDY CLAY	GREY	-	-	-	30	70	60	M	5.5		3.6	7.4	1.5	58	-	0.1	0.02	0.01		
5.	2.5 - 3.0	0.5	FINE SAND	GREY	-	-	5	35	60	20	F	5.5		4.	8.5	3.2	20	-	0.1	0.02	0.01		
6.	3.0 - 3.5	0.5	FINE SAND	[illegible]Y	-	-	10	35	55	20	F	5.5		5.	10.7	4.	20	-	0.4	0.08	0.04		
7.	3.5 - 3.9	0.4	FINE SAND	GREY	-	-	10	30	60	20	F	4.4		3.	5.6	2.4	20	-	0.3	0.10	0.04		
8.	3.9 - 4.5	0.6	SAND	GREY	5	10	20	25	40	20	F	6.6		4.5	8.7	3.6	20	TR	2.1	0.47	0.28		
9.	4.5 - 5.0	0.5	SAND	GREY	5	15	25	30	25	20	F	5.5		2.	4.5	1.6	29	-	3.3	1.65	0.83		
10.	5.0 - 5.5	0.5	CLAY SAND	GREY	-	15	20	30	35	30	M	5.5		3.	6.6	2.1	30	-	29.3	9.77	4.89		
11.	5.5 - 6.0	0.5	CLAY SAND	GREY	5	10	20	25	40	35	M	5.5		3.5	7.8	1.3	63	-	51.5	14.71	7.36		
12.	6.0 - 6.4	0.4	CLAY SAND	GREY	10	15	25	30	20	15	F	4.4		2.5	5.7	2.1	16	TR	34.	13.60	5.44		

BOTTOMED AT - m. on U B.

WO-H GRADE TO 6.4 m : 2.96 KG/m3

CONCENTRATE X. 725
Sn. ESTIMATED.

GEOLOGISTS COMMENTS GRAVELLY SAND WITH FRAGMENTS OF QUARTZITE AND LATERITE AT 6.4 M

Recovery 0 - 3 m = 77 %
Recovery 3 6.4 m = 63 %
Recovery 0 6.4 m = 69 %

REMARKS : Concentrate calculations over 0 - 3 m based on Theoretical Volume, from 3 m down on Recovered Volume. Cum Grade = $\frac{\Sigma \text{ Richness}}{\Sigma \text{ Thickness}}$

Drag Tin added where applicable. Maximum Richness Applied at mx kg/m3 where applicable.

79-1373