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REPORT ON TOUR OF MALAYAN TIN MINING AREAS, 27th MARCH - 19th APRIL, 1962.

by

J.G. Best.

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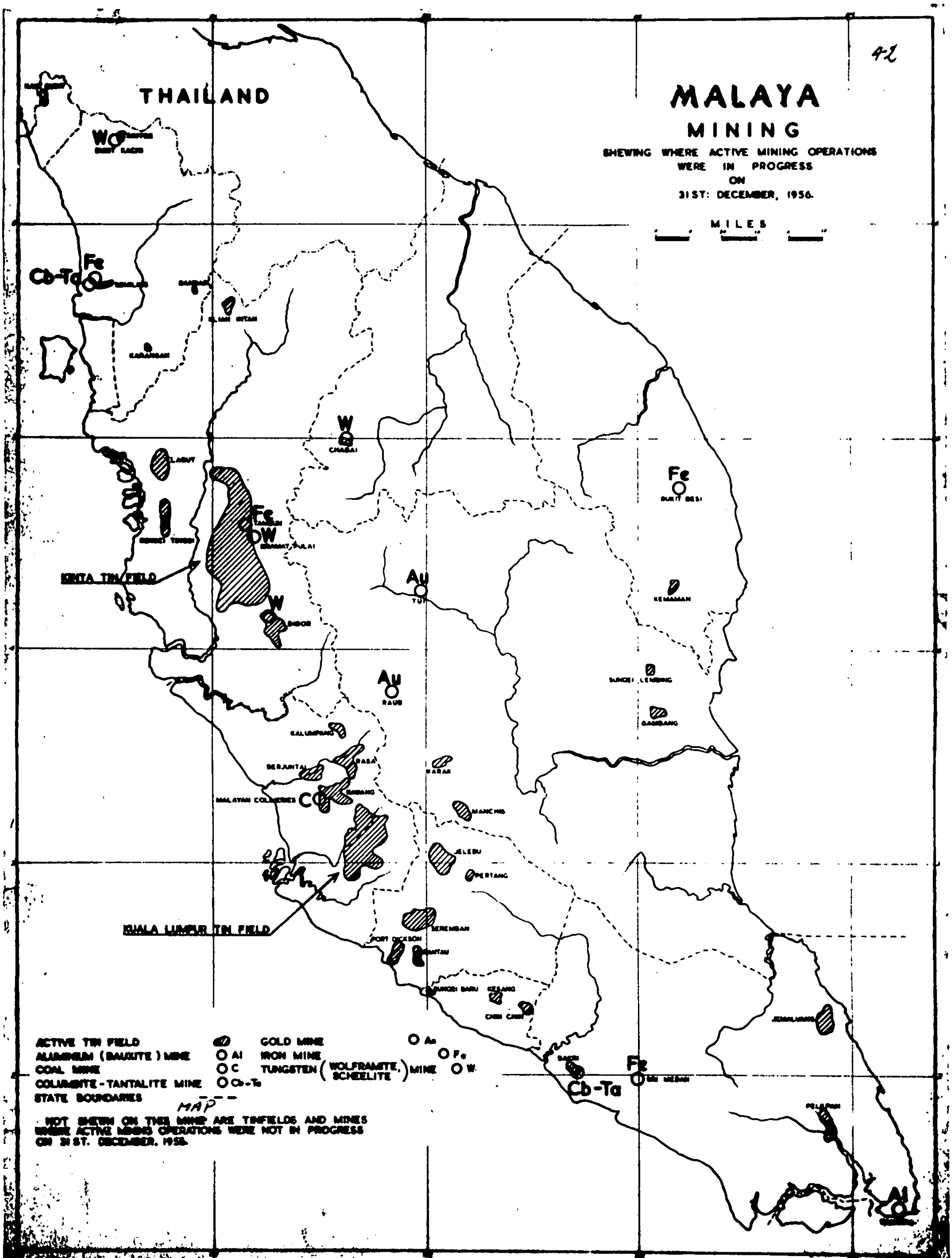

To accompany Record No 1962/106

REPORT ON TOUR OF MALAYAN TIN MINING AREAS,
27th March-19th April, 1962

SUMMARY

About three weeks were spent from 27th March to 19th April, 1962 on an inspection of the Malayan tin mining areas. During this time the tin mining and prospecting in six States,(including the richest tin field in the world - the Kinta Valley in Perak) and a tin smelter on Penang Island were visited.

Tin in Malaya occurs mainly on the western side of the Peninsula; it has been introduced by granite and most of the large tin deposits are in areas of calcareous sediments. As a result of the great depth of weathering most of Malaya's tin is mined from alluvial deposits, particularly placer deposits. Some tin is obtained from alluvial/eluvial and lode deposits. The placer deposits occupy broad, swampy valleys, which are difficult to prospect, but easy to dredge. The lode deposit at Sungei Lembing, Pahang, is reputed to be the largest lode tin mine in the world and has yielded 80,000 tons of tin concentrates since 1888.

Test boring of alluvial tin prospects is mainly by Banka drilling. Percussion drilling is used in other prospects. The results of boring are evaluated by core-volume measurements, the volume of core cut in each bore hole being measured in tenths of a quarter-cubic foot by means of a wooden box, or a volume bucket. These methods are not preferred to those at present used by tin companies in North Queensland.

Most of Malaya's tin has been mined by bucket-band dredges. The dredges currently treat 250,000 yards of ground per month and dig to depths of 60 to 80 feet. The two main methods used in open-cast mining are hydraulicking and mechanical excavating. Vertical gravel pumps for transporting ore to the treatment plant; trucks, conveyor belts, and aerial ropeways are also used in some mines.

In the treatment and recovery of alluvial deposits dulangs (wooden panning bowls), palongs, (sluice boxes), and jigs and cyclones (on dredges), puddles (broad, squat, steel tanks), and Humphrey spirals are used. The conventional type comminution and sizing equipment is used in the treatment of lode deposits.

The Mines Department, and several mining companies in Malaya are actively engaged in the recovery of fine ('slime') tin, and it is recommended that this problem should also be studied in Australia.

INTRODUCTION

During the 1961 field season three alluvial tin prospects were discovered in North Queensland by combined Bureau of Mineral Resources and Queensland Geological Survey parties. Subsequently the Bureau of Mineral Resources decided to bore two of these prospects to determine whether they contained economic concentrations of alluvial cassiterite.

In order to obtain first-hand knowledge of testing methods and to gain more experience of commercial tin occurrences, I was sent to Malaya to study the methods currently employed in testing alluvial cassiterite deposits. I left Australia on 27th March and returned on 19th April. During my stay in Malaya I studied tin mining and prospecting in the States of Selangor, Perak, Pahang, Kedah, Perlis, and Johore; and visited a tin smelter on Penang Island.

Most of the alluvial deposits now being mined in Malaya were tested and proved 30 to 40 years ago; but I was able to witness some boring and had discussions with a number of people who have been associated with testing alluvial tin deposits in Malaya and Nigeria.

In Malaya increasing attention is currently being paid to the recovery of fine ('slime') tin. The Research Branch of the Mines Department and several of the large mining companies have devoted a lot of time and effort to these investigations and have met with varying degrees of success. I spent part of my time observing operations and discussing processes with these people, because I am sure there is scope for this type of work in Australia. Not only would the application of these processes lead to increased recovery from operating plants (mills and/or dredges), but, it may lead to profitable retreatment of tailings dumps throughout the stanniferous areas of Australia.

ITINERARY

March, Tuesday 27th - 1720 hrs. departed Canberra in T.A.A. "Friendship".

2030 hrs. departed Sydney in B.O.A.C. "Comet".

Wednesday 28th - 0630 hrs. (local time) arrived Kuala Lumpur, Selangor, Malaya, and was met by Mr. B. Rae from the Australian High Commission. During the day I had discussions with members of the staff of the Australian High Commission, the Malayan Department of Mines, and Anglo Oriental (Malaya) Ltd.

1630 hrs. departed Kuala Lumpur per Malayan Airways D.C.3.

1730 hrs. arrived Ipoh, Perak, and was met by Mr. B.H. Flinter from the Malayan Geological Survey.

1800 hrs. attended a meeting of the Malayan Tin Industry (Research and Development) Board at the Ipoh Club. The subject discussed at this meeting was "Current Practice in the Boring of Alluvial Tin Deposits in Malaya", and dealt primarily with core measurement, and cassiterite recovery from bore samples.

March, Thursday 29th - Morning: with the Geological Survey of Malaya; met members of the staff, inspected their building, and examined rocks and mineral specimens.

Afternoon: met the Chief Inspector of Mines, Perak, Mohd. Sallehbin Abdul Majid, and arranged visits to mines in the states of Kedah and Perlis. Also met Mr.J.D. Hellings a Director of Osborne and Chappel, discussed Osborne and Chappel methods of prospecting alluvial tin deposits with him; and arranged a visit to an open-cast gravel pump mine on the granite/limestone contact at Sungei Lah, about 40 miles south-south-east of Ipoh.

Friday 30th - Morning: drove to Batu Gajah and examined Southern Malay Tin Dredging's Number 4 dredge, and the Seven Mile Tin Shed.

Afternoon: returned to Ipoh and spent the rest of the afternoon in the Geological Survey's Chemical Laboratory discussing methods of tin assaying.

Saturday 31st - Drove to Chenderiang (40 miles south-south-east of Ipoh) and examined the open-cast mine on the granite/limestone contact at Sungei Lah.

April, Sunday 1st - Observed.

Monday 2nd - Morning: drove to Menglembu (about 4 miles south-west of Ipoh and examined a Chinese operated open-cast mine on the granite/limestone contact.

Returned to Ipoh and examined an iron ore mine at Tambun about 4 miles east-north-east of Ipoh.

Afternoon: spent with Mr. P.M. Sheahan, Chief Research Officer of the Research Branch of the Malayan Department of Mines.

Tuesday 3rd - 0850 hrs. departed Ipoh per Malayan Airways D.C.3.

0945 hrs. arrived Kuala Lumpur - remainder of the morning spent with the Australian High Commission, and the Malayan Department of Mines finalising the itinerary for the remainder of the tour.

Afternoon: spent with Mr. J. Fletcher of Vallentine, Dunne and Associates, discussing current Malayan prospecting methods.

Wednesday 4th - Drove to Sungei Lembing, 30 miles west of Kuantan, Pahang, with Mr. W.W. Abel, the General Manager of Pahang Consolidated Company Ltd.

April, Thursday 5th - Morning: spent underground on Myah Main Lode.

Afternoon: spent in the treatment plant at Sungei Lembing.

Friday 6th - 0850 hrs. departed Sungei Lembing by car.

1015 hrs. arrived Kuantan - remainder of the morning spent with Mr. Starbuck, Mines Inspector, Pahang.

Afternoon: returned by taxi to Kuala Lumpur.

Saturday 7th - Morning: with Mr. J. Bean, Malayan Geological Survey, and Dr. P. Collenette, Borneo Geological Survey, examining the open-cast mines at Sungei Besi about 10 miles south-south-east of Kuala Lumpur.

Afternoon: with Mr. W.E. Bush, Eastern Mining and Metals Company, (formerly with Queensland Geological Survey) discussing prospecting techniques in Malaya.

Sunday 8th - Morning: with Mr. J.E.V. Collins, Malayan Department of Mines, to Rawang (20 miles north of Kuala Lumpur) to observe a Mines Department "Banka" drilling team test boring portion of a Malay Reserve.

Afternoon: observed.

Monday 9th - Drove with Mr. D. Davidson of Anglo Oriental (Malaya) Limited to the Berjuntai area (about 40 miles north-west of Kuala Lumpur) lower Selangor River. Examined No.4 Dredge, and the Tin Dressing Shed. Witnessed Banka drilling in swamp.

Tuesday 10th - Morning: returned to Sungei Besi to witness percussion drilling with a Goldfields rig in the area south of the Hong Fatt mine.

1630 hrs. departed Kuala Lumpur per Malayan Airways D.C.3.

1800 hrs. arrived Penang airstrip.

1930 hrs. departed Georgetown (Penang) by taxi with B.H. Flinter.

2245 hrs. arrived Alor Star, Kedah.

Wednesday 11th - Drove with B.H. Flinter and Tan Kim Bee, Inspector of Mines, Kedah to Kaki Bukit, and examined the Khai Fatt and Wang Tangga limestone-cave mines. Returned to Sungei Patani, Kedah.

April, Thursday 12th - Morning: drove to Penang and was conducted over Eastern Smelters Works in Georgetown by the Works Manager, Mr. Tolley.

Afternoon: returned to Sungei Patani

Friday 13th - drove to Klian Intan in Pahang (near Thailand border) and examined Rahman Hydraulic open-cast mine, and treatment plant. Returned to Sungei Patani.

Saturday 14th - Morning: drove to Semiling and examined open-cast alluvial/eluvial tin mines. This area is of interest because about 1/3 of the economic heavy mineral concentrate is columbite.

Afternoon: drove to Penang.

Sunday 15th - Observed.

Monday 16th - In Georgetown.
1830 hrs. departed Penang in Malayan Airways D.C.3.

2100 hrs. arrived Singapore.

Tuesday 17th - drove to Kota Tinggi, Johore with Woon Chow Kwai, Managing Director of Pelepah Kanan Mining Ltd., to examine the open-cast mine and treatment plant.

Wednesday 18th - 1230 hrs. (local time) departed Singapore in Qantas Boeing 707.

Thursday 19th - 0030 hrs. arrived Sydney.

0830 hrs. departed Sydney T.A.A. "Friendship".

0930 hrs. arrived Canberra.

DISTRIBUTION OF TIN DEPOSITS

The largest and richest deposits of cassiterite are along the western side of the Malayan Peninsula, from Perlis in the north to Johore in the south. Perak and Selangor contain the largest deposits and the Kinta Valley in Perak is reputed to have been the richest tin-field in the world.

The tin deposits along the eastern side of the peninsula have, with two exceptions, been generally small. The exceptions are (i) the lode mine at Sungei Lembing, which is reputed to be the largest lode tin mine in the world and (ii) a comparatively recent discovery at Jalan Lombong near Kota Tinggi, Johore where current prospecting has indicated reserves of about 45 million tons of 1 percent ore, all of which can be mined open-cast.

TYPES OF TIN DEPOSITS

The cassiterite throughout Malaya is closely associated with intrusive granite and was undoubtedly introduced by the granite. Two types of granites have been mapped one is a grey biotite granite, considered to be the tin mineralizer; the other is a grey biotite-hornblende granite, and appears to be devoid of tin.

The intruded sediments are dominantly argillaceous and calcareous, and most of the large tin deposits have been found in the areas occupied by the calcareous sediments. The depth of weathering has been great and the granite batholiths are well exposed. As a result most of Malaya's tin has been mined from alluvial deposits, and most of the country's known reserves of cassiterite are in alluvial deposits.

(1) Alluvial deposits

(a) Placer deposits: these have provided most of the tin mined in Malaya. The stanniferous alluvium has been derived from sediments and granites, primarily by chemical weathering, and the alluvium is dominantly in the sand/silt size-range. Where the cassiterite has been derived from granite/limestone contact zones it is commonly of high purity and assays up to 76 percent Sn or more.

The placer deposits occupy broad valleys and range down to 150 feet or so deep. They are commonly waterlogged and swampy, and although difficult to prospect, are easy to dredge.

(b) Limestone-cave deposits: in Perlis, the most north-westerly of the Malay States, stanniferous alluvium was deposited in limestone caves by former subterranean streams. The deposits are sporadically rich, but are virtually impossible to prospect.

(2) Alluvial/eluvial deposits

Along the contact between granite and limestone phenomonally rich deposits of cassiterite have been located and mined. Some of the cassiterite is well rounded and has apparently been transported by streams, but a lot of it is very angular and has obviously been shed, more or less in situ, from decomposed granite and limestone. The tin in these deposits ranges from large pieces weighing several hundredweight down to minus 300 mesh 'slime' tin.

(3) Lode deposits

(a) With quartz in stockworks in sediments. At Klian Intan in northern Pahang deeply weathered argillaceous sediments are being mined by open-cast. The tin is thought to occur in quartz veins which ramify through the sediments. The weathered sediments are mined non-selectively and recovery is said to average about 1 lb. of SnO_2 per ton.

(b) With sulphides in sediments. The Pahang Consolidated Company has been mining tin at Sungei Lembing, Pahang since about 1888 and has to-date produced about 80,000 tons of tin concentrates. The cassiterite lodes are in dark grey fine-grained phyllites. The gangue is dominantly chlorite with some quartz, calcite and a number of sulphides principally pyrite, chalcopyrite and arsenopyrite, with some sphalerite, galena, and bornite. Current annual production is about 2,500 tons of 72 percent cassiterite concentrates.

TEST-BORING TIN DEPOSITS

(1) Drilling

(a) Banka drilling. Probably 99 percent of Malaya's alluvial tin deposits have been proved by Banka drilling. The method is particularly suited to Malaya where an abundance of cheap labour keeps drilling costs low, and where extensive swamps preclude the use of heavy boring plants. The high cost of labour in Australia prohibits the use of this method here.

(b) Percussion drilling. Sungei Besi Mines Ltd., have been using three Goldfields churn drills to test-bore the Sungei Besi/Hong Iatt area. The deposits lie along a granite/limestone contact and due to the abundance of coarse fragments in the alluvium were virtually impossible to drill with a Banka drill, but the method of drilling is very similar to that employed in Banka drilling.

A drilling bit is not used, but a pump fitted with a clack-valve, but without a plunger, is attached to the end of the drilling line. This is operated in the usual manner and the pump gradually filled. The pump is withdrawn and discharged either by actuating the clack-valve or else unscrewing the foot of the pump, which contains the clack-valve. Only rarely do they have to use a chisel bit down the holes.

I know of no deposits in Australia where this method of drilling would be very satisfactory.

(c) Diamond drilling. Pahang Consolidated Company Ltd., use standard diamond drilling practice in prospecting the lodes, but I did not see them in action.

(2) Determination of core volume

The estimation of core volume is essential for evaluating the results of boring. All parties in Malaya are agreed on the necessity of determining the volume of core cut in each hole, but they are not agreed on methods employed in determining the volume of the core. The older method appears to be based on a wooden box 12" x 12" x 3" deep, and called a "quarter-cubic-foot-base". The cuttings are emptied from the pump into the base and rammed tight in an effort to simulate the conditions in situ. The volume is measured in tenths of a quarter-cubic-foot, and when used in conjunction with the weight of cassiterite determined on a Vallentine scale enables the value in katis/cubic yd. to be calculated directly (1 kati = 1 1/3 lbs.).

A variation of this method is the use of a box 12" x 12" x 4" deep in which the material is not tamped. It is still regarded as a quarter-cubic-foot base, but the extra 1" height is to allow for expansion of the cuttings.

The other, and more accurate method, is the use of a volume bucket in which the core is either measured directly or else by displacement of water. The quarter-cubic-foot is still the unit of measurement.

Neither of these methods seems particularly suited to Australian conditions, and I think the Bureau should follow the practice of Tableland Tin Company and Ravenshoe Tin Company and use the Pipe Factor method. In this method the area of the cutting shoe is calculated and the theoretical volume of the core which should be cut is obtained by multiplying the area of the cutting shoe by the distance advanced. The cuttings are measured in a volume bucket graduated in 500ths of a cubic yard and compared with the theoretical yield. The factor obtained is used to adjust the amount of cassiterite concentrate obtained from that section of the bore hole.

(3) Recovery of fine tin from bore hole samples.

In Malaya increasing attention is being paid to the recovery of fine tin (down to 300 mesh and finer). In the past the guiding philosophy has been "there is little point in recovering from a bore hole what cannot be saved on a dredge". But with tin reserves dwindling and little or no prospect of discovering vast new deposits, there is a growing realisation that recovery percentages must be improved as a conservation measure.

The Research Branch of the Mines Department has been concerned with this problem for many years, and have devoted their attention particularly to improving methods of recovering the fine tin from bore hole samples, not only in the "wash" beds, as is the practice with the mining companies, but throughout the entire hole.

The mining and prospecting companies reduce the sample to a final cassiterite concentrate at the bore site, and this figure, corrected to a 72 percent concentrate after assay, is plotted on their maps.

The Mines Department reduce the sample to a rough concentrate (taking care not to lose any heavy mineral) in the field and carry out final concentration in the laboratory at Ipoh.

The procedure followed by the Mines Department is:

In the field

1) Cuttings measured in a measuring can (graduated in tenths of ¼-cubic-foot).

2) Volume can and contents weighed on a beam scale as a check against volume measurement.

3) Cuttings puddled and decanted twice. All decanting done through a 300 mesh screen to avoid losing plus 300 mesh cassiterite.

4) Cuttings screened through ¼" and ⅛" screens and over-size put to one side and examined for specimen-cassiterite.

5) ⅛" screen undersize is reduced in a dulang (a wooden equivalent of a panning dish) to a rough concentrate. The concentrate is dried, weighed, packaged, and sent to the Research Branch at Ipoh.

At Ipoh

6) The sample is weighed, to check if there have been any losses in transit.

7) Screened through, 10, 30, 60, 100, 200, and 300 mesh screens, and each section hand-dressed to produce:

   (a) cassiterite concentrate which is dried and weighed and subsequently assayed;

   (b) 'amang' (heavy mineral residue) - later assayed;

   (c) tailings, random samples of which are assayed to check on the efficiency of the tin dresser.

   (d) magnetic mineral residue.

MINING METHODS

(1) Dredging

Most of Malaya's tin has been mined by dredges. At the height of dredging activity, pre-World War II, there were 126 dredges operating in Malaya. The number in commission now is much less.

The dredges are all bucket-band dredges commonly treating 250,000 yards or more of ground per month, and digging to depths of 60 to 80 feet. There are a few dredges working deeper ground, down to about 150 feet.

The ground is fairly easily dug, the major hazard being buried logs. The "karang" (wash layer) is rarely coarse; it is commonly in the grit/fine conglomerate size-range and is easily disposed of through launders at the rear of the dredge. Most dredges are electrically driven and are anchored by head lines; due to the easy digging, spuds are not necessary.

In the swampy areas of the lower Selangor River, Anglo Oriental have for years had difficulty in building bunds in dredged ground to control their effluent slimes. The tailings contained such a high percentage of water that it was virtually impossible to stack them above water level, and in order to build bunds, it was necessary to dig the tailings with drag-line-scoops. The resultant bund was never very stable. About two years ago they began experimenting with cyclones to dewater the tailings. The experiments were highly successful, and they now build bunds with the dredge that not only control the slimes, but are sufficiently stable to support roads and power line poles.

(2) Open-cast mining

(a) Hydraulicking. Alluvial cassiterite deposits along granite/limestone contacts are commonly worked with monitors fed by water under gravity or pumped by electric or diesel-powered pumps.

This method is particularly suited to areas where pinnacle limestone underlies the alluvium. Since most of the alluvium is in the sand/silt size range, practically all of it can be pumped out of the pit to the treatment plant, and the tailings are pumped away to tailing dams. Where boulders are encountered female coolies are employed to move and stack them.

(b) Mechanical excavators

(i) Mechanical shovels, both diesel and electrically powered, are used extensively in the open-cast mines. Commonly they are used in conjunction with monitors, digging the alluvium and dumping it within reach of the monitors, which flush the alluvium into the sump.

At Klian Intan, Rahman Hydraulic Tin Ltd., are using 4 x $\frac{3}{4}$ yd. and 2 x $\frac{5}{8}$ yd. mechanical shovels to dig weathered sediments containing disseminated cassiterite. The lode is on the flank of a steep hill and the mine is worked in a series of benches. About 1,000 tons of ore is dug per day, and recovery averages about 1 lb. per ton of 72 percent cassiterite-concentrates per ton.

(ii) Bucket-wheel excavators. Sungei Besi Mines Ltd., use a 50 litre bucket-wheel excavator to dig stanniferous alluvium/eluvium. This excavator is benching along the western (limestone) side of a granite/limestone contact zone. Formerly this open-cast mine was worked with monitors, gravel pumps, and mechanical shovels. The company plans to instal a 120 litre bucket-wheel excavator on the eastern (granite) side of the mine in August. These two machines will mine low-grade alluvium in north trending benches along both sides of the pit. They will widen the pit, reduce the batter, and ultimately permit mining of the rich stanniferous wash in the floor of the pit, already about 500 feet deep.

(3) Transport of ore.

(a) Gravel pumps. In the mines worked by monitors the stanniferous alluvium is pumped through pipe lines to the treatment plant.

Vertical gravel pumps are now extensively used in this type of operation. They have several advantages over the horizontal pumps:

(i) They are smaller and lighter than the horizontal pump.

(ii) The drive motor is mounted directly on top of the pump. Those driven by electricity are very efficient and robust, but the diesel-driven pumps have so far failed to give satisfactory service, commonly because the geared coupling fails after a short period of service.

(iii) The pump is suspended in the sump from a chain hoist. It does not need to be coupled to the sump via a long inlet pipe, and should the level of the sump rise rapidly the pump can easily be lifted above danger level. The outlet from the pump is coupled to the discharge pipe-line via a reinforced flexible rubber hose.

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(b) Trucks. Many of the mines, particularly the shallower ones, use tip-trucks to transport the ore, which is dug by mechanical shovels, to the treatment plant. It is not the most efficient method, because in wet weather the floor of the pit frequently becomes a quagmire. However, the trucks are the most flexible means of transport.

(c) Conveyor belts and aerial ropeways. Rahman Hydraulic Tin Ltd., transport ore from the mechanical shovels to loading bins on the crest of the hill by conveyor belts. From the crest of the hill to the treatment plant, 1¼ miles away and 800 feet below, the ore is transported by aerial ropeways which are gravity-driven and fitted with air-brakes. There are two aerial ropeways each with 86 x 2/3 cyd. buckets, and they travel at the rate of 100 buckets per hour.

In the mine there are three conveyor belt systems:

(i) Trunk conveyors - These are 24 inch belts more or less fixed in position, which travel at the rate of 320 feet per min., and transport 140 tons of ore per hour to the loading bins on the crest of the hill.

(ii) Face conveyors - These are 24 inch belts, travelling at 300 ft./min., which transport the ore from the mechanical shovels to the trunk conveyors. The face conveyors are moved around the mine to take ore from whatever face is being worked.

(iii) Hopper conveyors - When changing from dump trucks to a conveyor belt system one of the problems that confronted the operators of this mine was how to load a 24" belt from a ⅜ cubic yard shovel. They overcame the problem by building a hopper which discharges on to a 30" belt running over rollers about 6 feet apart. This belt is electrically driven (it derives its power from the mechanical shovel) and travels at 27 feet a minute and discharges evenly on to the face conveyor.

(4) Underground mining.

The Pahang Consolidated Company's mines at Sungei Lembing in Pahang are the only lode-tin mines worked by underground methods of any consequence in Malaya; and they are reputed to be the largest, underground lode tin mines in the world. The mines have been operated continuously under European management since 1888 (except for the period of Japanese occupation during World War II), and there is evidence of ancient surface workings probably carried out by Siamese and Chinese for hundreds of years past.

Since 1888 more than five million tons of ore have been mined for a yield of about 80,000 tons of cassiterite concentrates. Current production is about 17,500 tons of ore per month. The head assay is kept to about 1.24 percent SnO_2 and the annual yield is about 2,500 tons of 72 percent cassiterite concentrates.

There are six mines within the lease, namely Willinks, Gunong, Jeram, Batang, Semchang, Myah and Pollocks mines. At present Willinks and Myah are the two main producing mines.

In Willinks mine some of the levels are about 1 mile long; and in Myah mine ore has been proved over a vertical interval of 3,000 feet.

The lodes have been traced from the sediments into the underlying granite, where they become barren. There is no doubt that the granite is responsible for the introduction of the tin.

The ore is mined mainly by shrink stoping, but where the ground is not "free-standing", square sets are used. All stopes are subsequently filled.

TREATMENT AND RECOVERY METHODS

(1) Alluvial deposits

(a) Dulangs (pronounced 'doolung') are wooden panning bowls commonly about 2 feet in diameter and 6 to 8 inches deep. They are the Malayan equivalent of a panning dish. The dulangs are almost invariably operated by chinese women who are referred to as 'Dulang Washers'. The dulangs are used in all operations where concentrates are required, in prospecting, mining and the final cleaning up of cassiterite concentrates.

Dulang washers are paid $4.65 per day (about 13/6 Australian) and generally work a 6-and sometimes 7-day week.

(b) Palongs (sluice boxes) were formerly the main method of recovering alluvial cassiterite, both from hydraulicking and dredging operations. They were abandoned many years ago on the dredges in favour of jigs, and now they are slowly being replaced by jigs in hydraulic mines. A conspicuous feature of the palongs is their large size; they are rarely less than 100 feet long, and commonly nearer 200 feet. They are usually 6 feet wide, built in pairs and raised high (50 ft. or so) above the ground. The tailings discharge over the foot of the palong into a dam built with alternate layers of dewatered tailings and grass. The percentage recovery in palongs is not high, and many old tailings dams have been profitably reworked using jigs to recover the cassiterite.

At the Khai Fatt mine at Kaki Bukit in Perlis, the palong is fitted with a trommel instead of a grizzly, as is commonly the practice in Australia. The trommel is fitted with short vanes in the top end and the water discharging from the gravel pump-line falls onto the vanes and rotates the trommel. Unlike the fixed grizzly, the trommel does not clog.

(c) Jigs and cyclones. Jigs have been used on dredges in Malaya for at least 30 years. Not only did they improve the recovery percentage, but they also enabled a greater yardage to be treated.

Anglo Oriental (Malaya) Ltd. recently experimented with cyclones ahead of their jigs. The experiments were successful and now all four dredges working at Bejuntai are fitted with cyclones ahead of all jigs. The cyclones have cut down the volume of water passing over the jigs and the flow is now smooth and not torrential as it was without the cyclones. Since the cyclones were installed the recovery of heavy mineral (not necessarily all cassiterite) has been increased by 15 percent

The cyclones used to dewater the tailings on these dredges have already been mentioned; these cyclones are fed from sumps by vertical gravel pumps.

Anglo Oriental has rubber-lined all their jigs, and this has increased jig-life about 10 times.

Most of the jigs used in hydraulic mines are now using cyclones to dewater the jig-feed. Most of the jigs used by the Chinese miners in Malaya are manufactured in the country and are replicas of Harz, Bucyrus, and Denver types.

(d) Puddlers. The alluvium from mines along the granite/limestone contact commonly contains a lot of clay. At Sungei Besi mine the alluvium is discharged from the conveyor belt directly into puddlers. The puddlers are broad squat steel tanks about 10 feet in diameter, in which rotate (horizontally) four arms set at right angles. Heavy chains hang from the arms and puddle the alluvium as they rotate. Sand/sized and smaller fragments are discharged through screens in the side of the tank. The tanks are cleaned out manually at regular intervals and commonly yield about 1200 piculs (1 picul = 133 lbs.) of very coarse cassiterite, much of which is specimen.

(e) Humphrey spirals. Sungei Besi mine was the only place where I saw Humphrey spirals in use, but I believe other companies are experimenting with them. Their prime function is to separate quartz sand from heavy mineral, and to be efficient the feed must be evenly sized; so, unless the feed is classified the split is not very satisfactory.

(2) Lode deposits

(a) Comminution equipment

(i) Stamp battery. I saw only two batteries in use in Malaya, one was used by Eastern Smelting Company to crush the old firebricks prior to tabling for recovery of absorbed tin. The other was used by the Wang Tangga mine at Kaki Bukit in Perlis for crushing stanniferous wash cemented with calcareous cement.

(ii) Chilean mill. Rahman Hydraulic uses Chilean mills for fine grinding the feed to the sand tables.

(iii) Jaw crusher. Used by the Pahang Consolidated Company in their plant at Sungei Lembing for the primary ore crushing.

(iv) Ball mill. The plant at Sungei Lembing now uses ball mills in place of stamp batteries; they handle a greater throughput of ore and don't flour the cassiterite to the same extent that stamp batteries did.

(v) Rod mill. Rahman Hydraulic uses a rod mill ahead of the Chilean mills in the comminution of the stanniferous eluvium.

(b) Sizing equipment

(i) Screens

(a) Vibrating sections are used at Sungei Lembing and at Rahman Hydraulic for sizing crushed material.

(b) Arch-bend sieves. At Jalan Lombong, Johore arch-bend sieves are used for sizing feed to the jigs. They have the advantage that they pass material with only half the diameter of the sieve aperture, and consequently do not clog.

(ii) Rake classifier. The Pahang Consolidated Company uses rake classifiers to size the feed from the ball mills - oversize returns to the mill - undersize goes to the recovery plant.

(iii) Hydrosizers. The Pahang Consolidated Company uses hydrosizers to classify the feed to the shaking table.

(c) Recovery equipment

(i) Coarse tin

(a) Denver jigs are used by Rahman Hydraulic Tin Ltd. to recover the coarse tin before the eluvium is crushed in the rod mill.

(b) Sand tables. The Pahang Consolidated Company uses sand shaking tables to recover the coarse tin. The middlings from these tables are ground in the ball mill and treated with the rest of the slimes.

(ii) Fine tin. The Pahang Consolidated Company has increased its recovery from 75 to 94-96 percent by careful treatment of slimes. The improved recovery has enabled them to lower the head-value of the ore from about 3 to 1.24 percent and in so doing has facilitated mining and increased reserves. The mine produces 2,500 tons of 72 percent cassiterite concentrate per year, 18 percent of which is in the minus 300 mesh size range.

The fine tin is recovered by a combination of slime tables, tilting frames, and round frames.

The Pahang Consolidated Company is well in advance of any mining company in Malaya in the recovery of fine cassiterite; and most of the credit for this is due to the mill manager Mr. B. Grum, an ex-Pole, who claims that given the equipment he can recover even more tin from the slimes.

CONCLUSION

The tour, though of short duration, was most informative and extremely interesting. The hospitality was overwhelming, and all with whom I associated were most anxious to be of assistance.

I came home convinced that in Australia more attention should be paid to the recovery of fine tin. If Malaya, with its comparatively large reserves, is becoming concerned about the recovery of fine tin, then we with our limited reserves and increasing consumption should be even more concerned about it.

Such a project has two attractive features:

1) Suitable equipment, when developed, could be incorporated in existing treatment plants, and lead to an immediate increase in production.

2) We know the whereabouts of several tailings dumps which may contain economic concentrations of cassiterite. A programme for testing these should be initiated as soon as possible.

I suggest (1) may be undertaken jointly by the Bureau, A.M.D.L., and the Ore Dressing Section of C.S.I.R.O., and (2) be undertaken by the Bureau in conjunction with the State Geological Surveys and Mines Departments.