MINING IN MALAYA

THE MALAYAN INFORMATION AGENCY

MALAYA HOUSE, 57, TRAFALGAR SQUARE, LONDON, W.C.2

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BY

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SENIOR WARDEN OF MINES, F.M.S.

AND

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THE MALAYAN INFORMATION AGENCY,
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1940

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PREFACE.

THIS pamphlet has been altered considerably since the edition of 1931 by the late Mr. G. E. Greig. Much of it has been re-written, and nearly all the photographs are new. For some of the material thanks are due to the following:-

Messrs. D. H. Dillow and H. Davies, Federated Malay States Railways;

Mr. H. H. Robins, Malayan Collieries, Limited;

Mr. J. C. Coldham, Raub Australian Gold Mining Company, Limited;

Mr. V. B. C. Baker, General Manager, Pahang Consolidated Company, Limited. ;
The late Mr. E. Newbold, Eastern Smelting Company, Limited, and Officers of the Mines Department.

MINING IN MALAYA

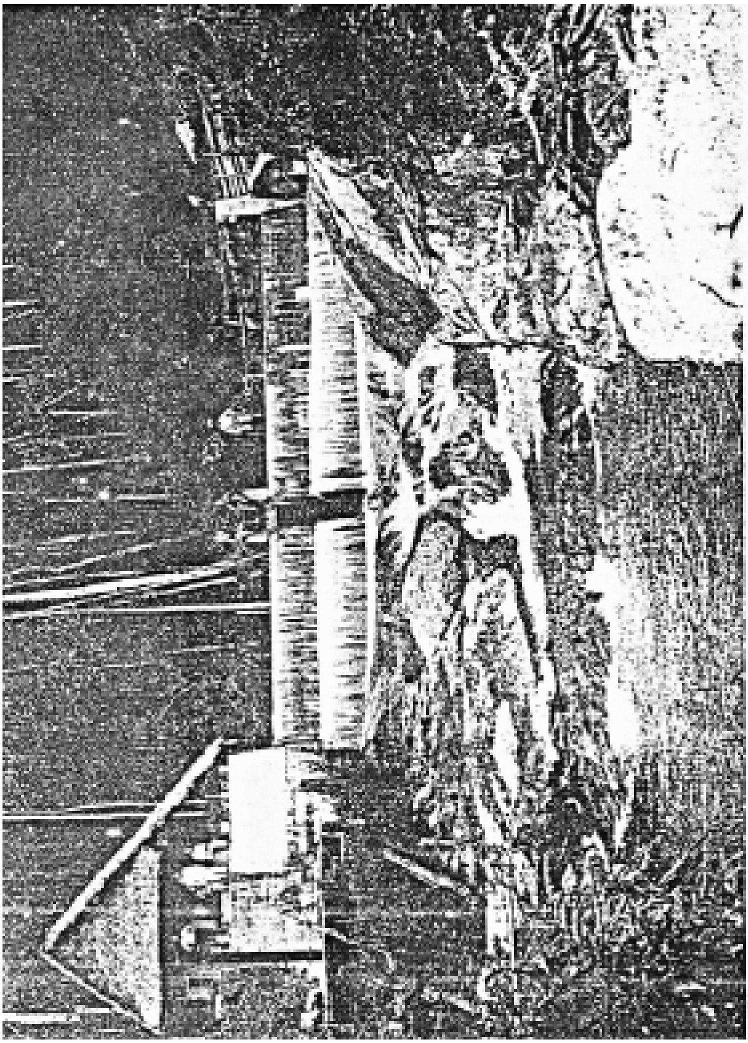
PREFACE TO 1939 EDITION.

THE information contained in this pamphlet has been revised and brought up-to-date both as regards statistics and text.

Notes on the Geology of Malaya have been revised by Mr. E. S. Willbourn, Director, Geological Survey, Federated Malay States.

Statistics are from Departmental records and also from the Statistical Year Book, 1938, issued by the International Tin Research and Development Council.

Information is given about the latest developments in dredging, gravel pumping, large open-cast mining and underground mining practice in the Federated Malay States. For these notes, thanks are due to Messrs. Anglo-Oriental (Malaya) Ltd., Messrs. Osborne and Chappel, Mr. R. Dillon-Corneck of the Societe Francaise des Mines d'Etain de Tekkah (French Tekkah Mines), Mr. V. B. C. Baker of Pahang Consolidated Company, Limited, the Federated Malay States Railway Department and the Eastern Smelting Company, Limited.



INTAKE FOR THE PIPE LINE OF A HYDRAULIC MINE.

MINING IN MALAYA

To speak of Mining in Malaya is to speak of tin-Mining for Malaya is the world's biggest tin producer. Tin mining is carried

Introduction

out in every one of the Federated Malay States, namely, Perak, Selangor, Negri Sembilan and Pahang, in each of the Unfederated Malay States, Kedah, Perlis, Kelantan, Trengganu and Johore, and in Malacca, one of the Straits Settlements. A little tinstone has been obtained from the Dindings, and it is known to occur in small quantities in Singapore Island. Most of the output of the Peninsula comes from alluvial deposits, but lodes and other ore bodies are also being exploited, and, indeed, one of the largest and most productive lode tin mines in the World is situated in Mal aya, a fact that is not widely known. There are other minerals mined, such as gold, coal, iron, manganese, lead, aluminium and tungsten ores, but tin-mining preponderates to such an extent that it almost completely holds the field. Similarly, when tin-mning is spoken of, it is assumed generally that mining in alluvium is Implied, owing again to the fact that by far the greater part of the mining is in deposits of that nature.

Conditions have altered very considera.bly since the inception of mining in Malaya. The gradual increase in the use of machinery, combined with its ever increasing efficiency has enabled the miller to tackle successfully deposits which, owing either to their depth, poverty of content, or wetness, could not be worked in the past at a profit.

The Perak River Hydro-Electric Power Company, Limited, in Perak, and the Government-owned Kuala Lumpur Power station, in the neighbourhood of Kuala Lumpur, have effected a great change in this respect. Electric power is rapidly replacing steam and oil on mines.

Out of a. total horse-power of 223,389 on mines in the Federated Malay States, 113,671 horse-power is supplied by elec tric power. As the richer and more easily worked deposits are becoming worked out, greater care has to be taken to mine efficiently and economically. The result of this is that the proportion of ore won by European methods as against Chinese methods has tended to increase, as shown in the following table. This increase has been arrested since 1931, due largely to the incidence of the Tin Control Scheme.

	European.	Chinese.
1920	36 per cent.	64 per cent.
1921	39 ,,	61 ,,
1922	38 ,,	62 ,,
1923	44 ,,	56 ,,
1924	45 ,,	55 ,,
1925	44 ,,	56 ,,
1926	44 ,,	56 ,,
1927	41 ,,	59 ,,
1928	49 ,,	51 ,,
1929	62 ,,	38 ,,
1930	63 ,,	37 ,,
1931	65 ,,	35 ,,
1932	66 ,,	34 ,,
1933	66 ,,	34 ,,
1934	66 ,,	34 ,,
1935	66 ,,	34 ,,
1936	67 ,,	33 ,,
1937	68 ,,	32 ,,
1938	67 ,,	33 ,,

The conditions above expressed call for mining on a large and comprehensive scale, adequately capitalized, in order that the ground may be mined cheaply and efficiently.

History of Tin Mining

The occurrence of tin-ore in the Malay Peninsula appears to have been known from very early days. There are more or less reliable records extant that the Ptolemies knew of these deposits at the time when the first Cornish tin mines were being worked. That the Chinese have been working these deposits for the last several centuries is much more certain. Their records of the early part of the nineteenth century speak of tin being found in the mountains of Malacca, and that men were sent to look after the mining of it. Malacca, in those days, included much more territory than the present Settlement.

D'Albuqucrque, the Portuguese conqueror of Malacca, mentions the suppression of the current Malay tin coinage In favour of his own currency, also made of tin. Chinese records again mention tin as an article of export from Johore and Pahang. The Dutch, in the seventeenth and eighteenth centuries, endeavoured to keep a monopoly of the tin produced in Kedah and Perak.

Towards the end of the eighteenth century the annual output from Perak was estimated at 5,000 pikuls (16•8 pikuls = 1 ton). The bulk of this tin was won by Malays in Kinta and Batang Padang. lntan, in Upper Perak, has been producing tin-ore for the last three hundred years at least. The discovery of the rich tinfields of Larut, however, was the main cause of the development of Malaya, because the faction fights which took place there between the various clans of Chinese in the seventies led to British intervention, and so, eventually, the present administration was evolved.

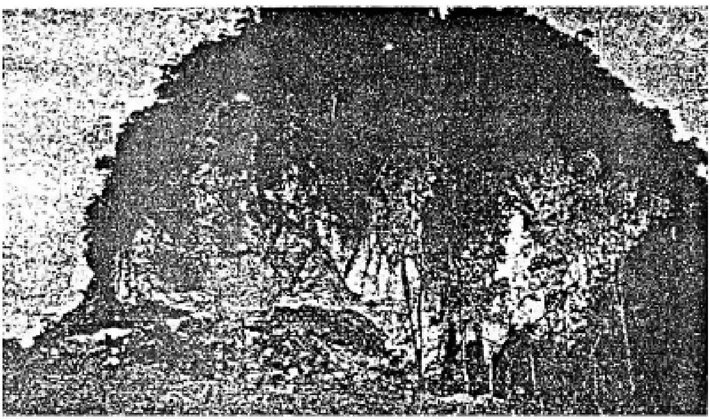
GEOLOGY.

Folding and Metamorphism

A geological map of British Malaya shows that the different rock formations occur as elongated outcrops, roughly parallel with one another and with the length of the Peninsula. This arrangement has come about as a result of folding movements which crumpled rock layers into a. succession of parallel waves that were later eaten into by erosion. Granite masses occupying some of the anticlinal cores have been laid bare, flanked by the upturned edges of the various strata that formerly overlay them.

The earth-movements were accompanied by great heat and pressure, which made radical changes in the nature of the rocks. Limestone became partly crystalline and where the folding was most intense) was metamorphosed to marble, a wholly crystalline rock.

Shale was altered to a large variety of rocks, from slate, phyllite, and schist, to a hard compact, flintlike rock known as hornstone, a material often selected by prehistoric man for fashioning his stone implements. The effect of pressure and heat on sandstone and conglomerate was to melt the comers of individual sand grains, so that the pebbles and grains became imbedded in a cement of crystalline quartz; a foliated structure may also have been imparted. The loosely knit rocks were converted into hard quartz-schist, quartzite, and quartzite-conglomerate. All these rocks were made impervious to water.



LIMESTONE HILL SHOWING HEAVY FALL

Rock Formations

The bedded rocks laid down before these folding movements are divided into two great rock-formations. The older rock comprises a calcareous series, of Carboniferous formations and Permocarboniferous age, and consists of interstratified limestone and shale, which, in the mineralized districts, ha\e been metamorphosed, as above described, to marble, slate, phyllite, or schist. Overlying is a sandy series, Triassic in age of conglomerate, sandstone, and shale, metamorphosed to quartzite-conglomerate, quartzite, hornstone schist, phyllite, or slate.

Granite and other indigenous rocks were formed during the period of folding. Zones of low pressure, located under layers of bedded rocks thousands of feet thick, became occupied by intensely hot molten rock welling up from below, and some intrusions were of enormous size. On cooling, the molten material solidified as granite or other plutonic rock, which, it should be emphasized, was buried under a thick cover of metamorphosed bedded rocks. Slight differences in the chemical composition of the original melt resulted in differences in the solids; hornblende-granite, syenlite, diorite, and gabbro were variants. The mineral wealth of Malaya has been derived from granite; little or none of it has come from the other igneous rocks. Finely crystalline or coarsely crystalline rock-types resulted from greater or less speed in cooling or from variation in the quantity of fluxes present.

Granite

The Main Range granite is an intrusion more •than 300 miles long, and the width of its exposed outcrop is as much as 30 or 40 miles. The tin-fields of Kinta, Kuala Lumpur and Taiping are located near the west side of it; other smaller granite intrusions have been responsible for other Malayan tin-fields. These tremendously large reservoirs of hot viscous liquid, buried under their thick cloak of crystalline limestone, schist, and quartzite, took millions of years to cool. Earth movement continued during the process of consolidation, so that fissuring and foliation occurred even in the granite itself, particularly along the margin of the intrusion. Faults resulted, and a. system of joint-cracks was formed everywhere by the shrinkage that accompanied cooling.

Origin of Materials

Most of the tin, tungsten, gold, iron, lead and other metals, originally present in small proportions in the molten material that solidified as granite, became concentrated into a residual hot liquid, under pressure, far down under the consolidated rock. Some of the fault-fissures and joint-cracks penetrated to this metal-bearing liquid, which, thereupon, was forced up and became deposited in them, in the granite, or in the meta morphosed rocks near its periphery. Most of the resulting mineral-veins were small, but some were wide enough and long enough to be termed lodes.

Alluvial Tin Deposits

Long after this time, Malaya was elevated from the sea floor to be part of a continent, and a. period of severe erosion ensued, during which tens of thousands of feet of metamorphosed rocks were removed, and the cores of granite and other igneous rock were laid bare. The larger granite masses formed high mountain ranges, flanked by foothills of schist, quartzite, and crystalline limestone, with plains of limestone and shale alongside them. The erosion of the tin-veins resulted in the extensive alluvial tin-deposits of Malaya, and the characteristically pitted surface of the limestone plains formed an efficient trap for the retention of the heavy mineral grains.

Before the formation of the alluvial tin• deposits, in Tertiary times, coal-bearing strata were deposited in lakes, which occupied a comparatively small area of Malaya. After their deposition and consolidation, they were partly removed by denudation.

Coastal Plains

The coastal plains are of recent origin, built of alluvium deposited by rivers as they entered the sea, and were formed after the alluvial tin-deposits had been deposited. Bore-holes sunk in these plains show a. succession of lens• shaped layers of sand and sandy clay resting on the upturned eroded edges of crystalline rocks.

Tropical Weathering

In the hot moist climate of Malaya, with rain falling almost every day, few rocks are proof against the continuous Tropical solvent action of water, and not one of the ordinary Weathering, rock-forming minerals is entirely resistant. When quartzite and quartzite-conglomerate are exposed to weathering, their quartz-cement is dissolved, and the impervious rocks are changed to become porous once again. The minute quartz-veins occupying foliation-planes in some schists are rotted by weathering, and, if they contain tin-ore, it can be cheaply extracted by methods of alluvial mining. Granite is just as liable to decomposition as the bedded rocks, and the weathered zone may exceed one hundred feet in depth.

Limestone differs from other rocks in being comparatively much more soluble in water, and its denudation has given rise to striking topography, with very Limestone. cliffs rising vertically from alluvial flats. In some districts these flats have li mestone bedrock partly laid bare by mining excavations. Such limestone pavements were long ago planed level by the sea waves, and since then incised by stream channels, and pitted with holes made by solution. Especially deep troughs are located where limestone is in contact with an insoluble rock, such as granite, and, where the contact-rocks were mineralized, the troughs contain detrital tin-ore.

Weathering of Limestone

The cover of alluvium laid down upon the pavement after the recession of the sea has not entirely protected the limestone from further erosion, for there has always been a copious supply of water continually working to deepen the solution-hollows. Thus the tin• bearing sand and clay have been affected by repeated subsidences, and beds originally horizontal have been tilted, so that, in extreme cases, they are now dipping vertically. This phenomenon calls for s pecial care in prospecting alluvial tin• deposits that rest on limestone; it may happen that a bore is so sited as to pass through the whole length of such a vertical layer, thus giving a very rich apparent value, whereas a bore only a few feet away might miss the rich bed altogether.

Its Effect on Prospecting

It has recently been established that the limestone of Kinta contains at least one bed of shale, varying from fifty feet to several hundreds of feet in thickness, interstratified with it, and that some of the shale has been metamorphosed and mineralized. It has been seen in a number of cliff-sections, difficult of access, and also in a few mines which happen to have been located exactly on the line of a shale outcrop previously hidden by alluvium. Mines on either side of the shale have floors of limestone. Much of the enclosing limestone has been dissolved by ground water, so that the shale would have been left, “in the air” but for t he fact that it

Tin Ore in Boulder Clay

was softened and weathered by the same agency and therefore collapsed to be mixed up with the neighbouring alluvium. This explains the origin of certain masses of sandy boulder clay, some of it containing tin-ore, that have long been known to occur in Kinta

PHYSIOGRAPHY.

The Malay Peninsula lies between the first and the sixth parallel, and between east longitudes 100º and 104º. It has for its main physiographical feature the great chain of granite mountains, in places rising to over 7,000 feet, forming the Main Range, which stretches from beyond Perak in the north to Negri Sembilan in the south.

One of the features to the east of the Main Range is a huge isolated mass of granite, syenite, and hybrid basic rocks, known as the Benom Range, which rises to a height of 6,916 feet. Gunong Tahan, 7,186 feet, the highest mountain in the Peninsula, forms part of a range of quartzite, shale and conglomerate extending from Pahang into Kelantan.

The physical features of the western part of the Peninsula, where the important tin fields are situated, are very fine. The mass of the jungle-covered Main Range, with its many high mountains, forms a magnificent background to the valleys beneath it. The subsidiary hills add to the beauty of the landscape. Some sunrise effects are extremely striking, with pure white clouds lying in the valleys, amongst dark patches of shadow; but it is in the evening that the mountains a.re seen at their best, bathed in glorious sunsets, the colour effect of which is beyond description.

Malaya is watered by many streams, of which the Pahang River, 250 miles long, and the Perak River, 170 miles long, are the largest. The Perak River has an average flow of 9,000 cubic feet per second. Wherever there is no mining or agriculture, the country is under jungle-a dense mass of trees, varying from pigmies to veritable giants. In the plains the undergrowth is so thick with creepers and thorns that the would -be explorer must cut his way through it;

Usually in the hills, the smaller vegetation is not so rank, and, in places, the floor of the forest is almost clear. The whole earth is impregnated with suppressed plant life, however which at once grows up when a clearing is made.

Because of the thick foliage, one's range of vision is limited to ten or twenty yards, and although the jungle teems with wild game, yet, except for monkeys, animals are rarely seen. Evidence of their presence is given by a network of paths, along which may be recognized the tracks of elephant, rhinoceros, tiger, tapir, deer, pig and numerous other creatures. Frequently the traveller finds these paths a help, but a disadvantage is that they are infested with leeches, which abound in wet weather and add to his many discomforts. Snakes, although common everywhere, are met in open country more often than in jungle. Cases of snake bite, however, are rare.

Climate and Rainfall

In the plains, where most people live, the climate is hot and moist, the temperature varying between 97° F. in the daytime and 68° F. at night. The humidity is high, the mean being about 82 per cent. In contrast, the climate at the various hill-stations is very pleasant, and the European schools at Cameron Highlands and Fraser's Hill enable parents to keep their children in Malaya longer than was formerly the case.

The country is subject to two monsoons, the south-west from May to October, and the north-east from November to March. The west side of the Peninsula is protected from the south-west monsoon by the bulk of Sumatra, and from the other by the Main Range, so that climatic changes are slight. There is, however, a tendency towards drier weather in June, July and August, and rain in the last three months of the year. The east coast receives the full force of the north-east monsoon. Throughout the Peninsula there is seldom a spell of more than three weeks without rain, and, even in such dry periods, there is a copious supply of dew.

In the hills the rainfall is very heavy, an average of 258 inches a year having been observed over a space of seven years was observed in one station on the plains. The average annual rainfall away from the mountains may be taken at 90 inches.

THE MODES OF OCCURRENCE OF TIN ORE.

Tin ore, invariably in the form of the oxide, cassiterite, Sn02 is found in many shapes and forms. Sometimes, but rarely, it is found in large crystals, but usually it occurs as sand with various sizes of grain, from pieces the size of a pea down to the finest flour. The colour, though generally a brownish-black, varies through clear white, green, ruby-red to almost pure black.

It usually occurs in layers of detrital gravel (derived by erosion from mineralized granite and adjacent metamorphosed rocks) with quartz pebbles and white clay, underlying alluvium which may or may not contain tin ore. It is found in situ, in stringers and veins in granite, schist, and mixed with arsenical pyrites and iron pyrites in limestone. It has been found in the form of brown sand. cemented together by calcite, also in considerable quantity in boulder clay.

The richest deposits are found at the contact of granite with limestone and other rocks. Bedrock in the Kinta Valley consists mainly of limestone, and the hills on either side are tin-bearing; a bird's eye view shows two continuous lines of mineholes along the valley sides, with u. zone of agricultural land intervening in the centre.

Near the east coast of Pahang there is an extensive deposit worked by the Pahang Consolidated Company, Limited. A large series of lodes occurs in schist and continues through to the granite, although they are mined only in the schist, because their tin contents in the granite are low. This mine is one of the biggest tin producers in the world , and great developments would be possible if the Tin Restriction Enactment did not forbid them.

MINERALS OTHER THAN TIN ORE.

The ores of tungsten, wolfram and scheelite, are of importance in Malaya, and arc mined in localities where tin ore also occurs.

Tungsten Ore

They owe their origin to granite. The largest deposits of wolfram are found In Kedah and Trengganu, located in schist near granite.

Scheelite is found near the contact of limestone with granite at several places in Perak and Selangor, and the Kramat Pulai deposit was one of the richest in the world, until it gave out in 1039. This one mine made Malaya the third largest producer of tungsten ores for the years 1933 to 1936 inclusive.

Gold

Approximately 29,000 ounces of gold were produced in Malaya in each of the years 1933, 1934 and 1935, and the figures for 1936,1937 and 1938 were 37,779 ounces, 34,347 ounces and 40,210 ounces. The output for 1938 constituted a record. Recent geological investigation has shown that this metal also, like tin and tungsten, owes its origin to granite. In several of the districts where gold has been found , it is associated with a fine-grained variety of granite in which felspar has undergone a partial or complete alteration to muscovite mica. This aplite or quartz-muscovite rock occurs as dykes, and in one case, as an intrusion with width of outcrop of one mile .

Gold quartz is widespread in a certain belt, trending a little west of north, from the boundary between Malacca and Negri ScmbiIan into Thai territory, but the only known lodes of any size are those of the Raub Australian Gold Mining Company. Here they occupy almost vertical), compressional fault-fissures, located between the bedding-planes of calcareous shale in a zone about three miles long, near the Bukit Kajang range of granite porphyry. Their gold-content varies from the merest trace to an ounce or more per ton. Only certain parts of the lodes contain payable ore and these ore-shoots are mined while large quantities of non-payable stone are left untouched. The lodes vary in width from a few feet to 75 feet. At that section of the mine known as the Raub Hole, a different kind of lode is being mined, quartz-stringers only a quarter of an inch to two inches thick, occupying tension-fis sure cracks located at right angles to the compression faults. They contain very high values of gold, but a large amount of barren rock must be mined to obtain a comparatively small quantity of the ore.

Other prospects have revealed gold quartz that is locally quite rich, but no lodes comparable in size with those at Raub have been found. The deposits pinch out. Lens-shaped masses of gold-bearing quartz have been located in phyllite, and thin unpersistent veins are known also in granitic rock and dolerite, but successful lode mining calls for deposits that can yield a more steady production than is to be expected from erratic occurrences like these. Detailed geological surveys of parts of the Malayan gold-belt are now being made in order to estimate the potentialities of lode mining.

Gold is obtained by mining alluvial deposits also, the figures for 1936, 1937 and 1938 being 9,968 ounces, 10,021 ounces and 9,695 ounces. In 1938, there were eight alluvial gold mines producing 3,000 ounces of gold in north-west Pahang, and a mine near the Sungei Lui, not far from Pasoh, in Negri Sembilan, had an output of 577 ounces. These properties are mined for gold alone. West of the Main Range are a number of tin mines producing gold as a by-product. The outputs from such mines near Bidor, Perak, during the years 1936, 1937 and 1938 were 7,789 ounces, 7,043 ounces and 5,444 ounces. Here the mining is done with gravel pumps. In Selangor, more than 500 ounces were recovered by treating the till ore concentrates 'won by certain dredges in the year 1938.

Iron Ore

Malaya's position as an important Eastern producer of iron ore has been firmly established, as shown by the export figures for the last five years given in the following table. All of it went to Japan:-

	1934	1935	1936	1937	1938
	Tons	Tons	Tons	Tons	Tons
Johore	578,180	594,887	590,287	465,486	549,960
Trengganu	557,468	817,334	1,064,259	1,024,215	905,316
Kelantan	—	—	—	49,223	159,900
Other parts of Malaya	—	—	—	278	366
	1,135,648	1,412,221	1,654,546	1,539,202	1,615,542

The chief sources of output are the Sri Medan Mine in Johore and the Machang Satahun Mine in Trengganu, both owned by the Ishihara Sangyo Koshi, the Bukit Besi Mine in Trengganu , twenty miles upstream from Kuala Dungun, owned by the Nippon Mining Company, the Temangan Mine in Kelantan, owned by the Southern Mining Company, and the Iizuka Mine on the Sungei Sembrong in the Endau district of Jobore. Haematite constitutes the bulk of the ore at the Sri Medan, the Machang Setahun, the Dungun and the Iizuka mines; limonite is the common mineral at the Temangan Mine. A deposit of haematite at Tambun, near Ipoh, Perak, is mined for use as ragging in dredge-jigs, and 923 tons were produced for that purpose in 1938, 366 tons of it having been exported.

Some of these deposits of iron ore are primary and owe their origin to granite or to intrusions of allied igneous rock. Others are secondary, derived from the decomposition of shist, slate, quartzite, or whatever is the bedrock underlying the deposit; the originally small proportion of iron minerals in a large quantity of rock has been accumulated in a concentrated form in the soil.

It is probable that there remain considerable supplies of iron ore not yet located, hidden at present by the thick cover of soil and vegetation that obscures so much of the surface of the country. Prospecting has already revealed some new deposits. Nearly one million of haematite have been estimated to occur in the Gunong Lesong Forest Reserve and large deposits have been proved at Ulu Rompin and Sungei Bebas in Pahang.

These occurrences of high-grade ore are quite distinct from the concretionary deposits of ironstone, very wide-spread throughout Malaya as a surface formation formed by weathering but too shallow and containing too small a content of iron to be of commercial value as iron ore. The concretions are known as a "laterite". They find a local use as road-metal.

As much of the iron ore of Malaya owes its origin to granite, the parent rock of primary tin ore, it comes as no surprise to learn that certain iron ore deposits contain appreciable quantities of cassiterite, and, indeed, permission to mine newly prospected deposits of iron ore is now withheld until it has been established that the release of exports will not contravene the Tin Restriction Enactment by allowing extractable tin ore to leave with them.

Tin Ore in Iron Ore

At Pelepah Kanan, Kota Tinggi, Johore, a large deposit of haematite and magnetite, forming a hill four hundred feet above the surrounding country, lies within a mass of metamorphosed rocks intruded by a boss of hornblende-granite porphyry and veins of pegmatite. Hundreds of assays of the iron ore show that so small an amount of tin as 0-1 per cent. Is rare; some samples contain more than 1•0 per cent.

Manganese Ore

Manganese ore is being shipped to Japan from two mines in Kelantan and Trengganu, export figures for the last five years being:-

	1934	1935	1936	1937	1938
	Tons	Tons	Tons	Tons	Tons
Trengganu	9,681	17,412	26,773	23,126	23,054
Kelantan	8,969	10,679	10,006	8,796	8,916
	18,650	28,091	36,779	31,922	31,970

The ore deposits form cappings on hills where they have been derived from the surface concentration of the manganese containing minerals originally present in underlying slate and quartzite. The payable ore does not extend to any great depth from the surface, not much more than twenty feet. As the ore is harder than the decomposed sedimentary rocks of the neighbourhood, a deposit naturally forms a hill, the size of which gives an approximate measure of the quantity of ore available.

Bauxite

Bauxite, ore of aluminium, is being mined in Johore for shipment to Japan, and export figures for the last three years are;-

1936	1937	1938
36 tons.	12,628 tons.	55,751 tons.

Bauxite is impure hydrated oxide of aluminium occurring as concretions in soil and subsoil varying in size from small granules to masses several feet across. In colour, the concretions vary from white, through yellow, to red, according as they contain a small or large amount of iron oxide. They are irregular in shape, and many are cellular in texture, the cavities being filled with clay; in the process of mining it is usual to wash away as much clay as possible, to obtain a better product.

The bauxite has been formed from the decomposition of other rocks by weathering, and, therefore, it is essentially a surface deposit, limited in depth by the extent to which the weathering agents have had access. Combined silica, lime, magnesia, soda and potash have been removed in solution from the parent rocks, and a hydrated mixture of oxides of aluminium, iron and titanium has been left, a special variety of "laterite" containing a high proportion of aluminium hydroxide.

Many of the bauxite occurrences in Johore have resulted from the weathering of those varieties of ancient igneous rocks that do not contain very high silica-percentages, and prospectors should search particularly those areas marked on the geological map of Malaya as containing rocks of the Pahang Volcanic Series. The more acid members, however, do not afford a promising field. For instance, the large outcrop of rhyolite at Tanjong Cherating, Pahang, has yielded no bauxite concretions.

All the bauxite so far discovered is located at heights not more than two hundred feet above the sea and the Bukit Pasir deposit near Baht Pahat continues to a depth actually below present sea-level.

Ilmenite

Ilmenite is ferrous titanate FeTiO3, a mineral that, in its pure state, contains 52•7 per cent titanium dioxide; however, it has happened usually that some of the titanium oxide has been replaced by ferric oxide. To be saleable in Malaya, the mineral should contain not less than 48 per tent. TiO.

Ilmenite is the chief constituent of "amang" in North Malaya, "amang" being the heavy, dark-coloured residue after the separation of tin ore from alluvial deposits. It is estimated that there are more than 350,000 tons of it already collected in dumps in the tinfields.

The price obtainable is probably less than £2 per ton, delivered in Europe, and, besides a purchase cost of five or six shillings per ton payable at the mine, there is a rather heavy charge for transport to the sea, because, unfortunately, our important Malayan tinfields are all situated inland. There is not much margin between costs and selling price and it is not expected that Malaya will ever be a keen competitor with India as a source of supply. Export figures for the last five years are given for comparison with the corresponding outputs from India, the world's chief source of supply.

	1934	1935	1936	1937	1938
	Tons	Tons	Tons	Tons	Tons
Malaya	50	3,000	10,314	6,252	6,462
India	75,644	127,051	140,477	181,047	252,220

The chief use of the mineral is as the source of titanium paints. The dioxide, titanium white, is also ideal filler because of its covering power and perfect whiteness. It is used as a pigment in the plastic industry, as, for example, in Bakelite, and is also employed in the manufacture of linoleum, coated textiles, rubber, wallpapers, printing inks, glass and enamel ware.

Zircon

Another constituent of "amang" is the mineral zircon, silicate of the metal zirconium. The United States market is improving, imports being I¾ million pounds in 1934, 5¾ million pounds in 1935 and 11½ million pounds in 1936. During 1936, zirconium ore containing 55 per cent ZrO_2 was quoted at $60 (American Currency) in five-ton lots.

The main uses of zirconium compounds are in enamels, in electrodes or welding-rod coatings, as refractories and as a scavenger for oxides and nitrides in steel. Little or no zircon has yet been exported from Malaya but it is anticipated that certain tin dredging companies that use magnetic separators for ore-dressing could supply the mineral in saleable condition.

Monazite

Monazite is also found in "amang" associated with tin ore, but only in small proportions. As the market is uncertain, there have been no exports from Malaya.

Arsenopyrite

The present price of arsenic is too low to permit of mining arsenopyrite except as a by-product obtained from tin- mining. Large quantities were once produced at the Beatrice Mine, Kinta, from a tin-bearing "pipe" in limestone near granite, but no appreciable amount has been exported during the last few years.

Galena

Small trial shipments of galena have been exported from Pahang, but it has not been proved that there is a large deposit of the mineral.

Coal

Coal of Tertiary age is being successfully mined by Malayan Collieries Limited, at Batu Arang in Selangor, and the total production from 1915 till the end of 1939 has been approximately 9 million tons. Large reserves are still available. Although the coal is of a type not suitable for storage for more than a limited period, yet it is a very valuable to the country as a source of cheap power.

Vertically or steeply dipping veins of coal of fair quality are found in alluvium in various parts of the country, but they have no commercial value because the quantity is insufficient for mining. Its age must be reckoned in mere thousands of years as compared with the million-year-old fuel on the property of Malayan Collieries, Limited.

Oil

It is not considered that there is any likelihood of finding oil supplies in Malaya, because most rocks are crystalline, impervious, and therefore incapable of functioning as reservoirs. The only favourable strata are of Tertiary age, the known occurrences of which, unfortunately, have but limited lateral extent. It is possible that other areas of

Tertiary rocks lie hidden under the extensive swampy plains of coastal alluvium, but there is no evidence that such is the case. An unsuccessful attempt to find oil near the mouth of the Bernam River proved about four hundred feet of alluvium overlying quartzite and metamorphosed shale. mineral oil does occur in the shale associated with the Tertiary beds of Selangor, Perak, Perlis and Johore, but not in sufficient quantity to repay distillation.

Limestone

Limestone occurs as large isolated masses that can easily be quarried, and some of it can be used as ornamental marble. Great quantities are available as road-metal and as railway ballast. It is used also in the building trade and, in selected localities, will be useful in the manufacture of cement.

Silica

Vast quantities of quartz are easily accessible as huge reefs in various parts of Malaya, and, if ever a sufficient demand for a silica refractory brick arises for use in smelting furnaces or in foundries, there is a tremendous amount of raw material available.

Phosphate

Phosphate is found as an earthy material on the floors of caves in limestone hills, but no deposit large enough for commercial exploitation on a considerable scale is expected.

Kaolin

At least one large deposit of fluorspar is known in Malaya, but as yet, it has no commercial value. Kaolin or china clay is mined on a small scale near Tapah in Perak and at Cheras in Selangor for local use as a filler in the manufacture of rubber goods.

Outputs for the last three years were:-

1936	1937	1938
121 tons.	263 tons.	385 tons.

Large supplies are available in the Tronoh and Bidor districts, and other sources could be found if required, but the small quantity is sufficient at present to supply local needs.

PROSPECTING.

Prospecting Alluvial Rock

The prospecting of alluvial deposits and soil in Malaya is done, nowadays, almost entirely by drilling, less often by sinking pits. Drilling is essentially the removal of a cylindrical section, representative of the deposit from surface to bedrock. From this is deduced the nature and economic content per cubic yard of the deposit at the particular point selected. If a large number of drill-holes be put down, an accurate idea can be gained of the nature of the whole of the alluvial deposit and the approximate value of its minerals can be ascertained.

The apparatus used for prospecting alluvial deposits in Malaya is the hand-drill. It consists of a steel cutting-tool screwed to the end of a string of steel rods, of handy size and weight. These are screwed together and operate inside a cylindrical steel pipe, usually 3½ inches in diameter, provided with a cutting shoe, so that, as the casing is forced into the ground, it outs out a cylinder of earth which is broken up by the cutting tool. . To remove the broken material the rods are withdrawn, and a hollow cylinder, fitted with a valve is attached in place of the chisel. By pressing and turning this against the bottom of the hole it is filled with the debris resulting from the work of the chisel. It is then pulled to the surface and emptied, the valve preventing the escape of the material while it is being raised. In clayey ground advance may be made with a scoop or augur, which, besides cutting the ground, will raise it and remove it from the casing.

The drilling is done from a platform fixed to the casing. The rods are lifted by special tools and allowed to drop, causing the chisel to cut into the ground at the bottom of the hole. Then the casing is sunk by rotating the platform, with h men still standing upon it. More casing and rods are added as the hole deepens. The ground recovered from the hole is measured, and the tin content ascertained by washing and assaying.

Scout bores may be anything from 9 chains of 66 feet to 20 chains apart, but, for the estimation of the value of a property, the average depth and value of the bores is taken to apply to the whole cubic contents of the property, deductions being made for any isolated and abnormally rich bores, and for irregularities in the rock bottom.

Prospecting in Rock

The prospecting in a well-organized lode mine, like that owned by the Pahang Consolidated Company, Limited, is conducted by sinking shafts, and driving levels and cross-cuts in those directions that are suggested as the outcome of long experience in the mine.

Diamond drills are used for the exploration of lodes in hard rock in Perak, Selangor and Pahang, and some boring has been done with calyx drills in soft Tertiary strata on the property of Malayan Collieries, Limited. An extensive prospecting campaign by means of diamond drill is being carried on in the mountains of the main range in the Ulu Selangor and Bentong districts of Selangor and Pahang respectively. The objective is to prove the continuation in depth of the lodes that have been exposed by ground sluicing in the past. This method of prospecting lodes is much cheaper and quicker than by driving adits and sinking shafts

PRESENT MINING METHODS.

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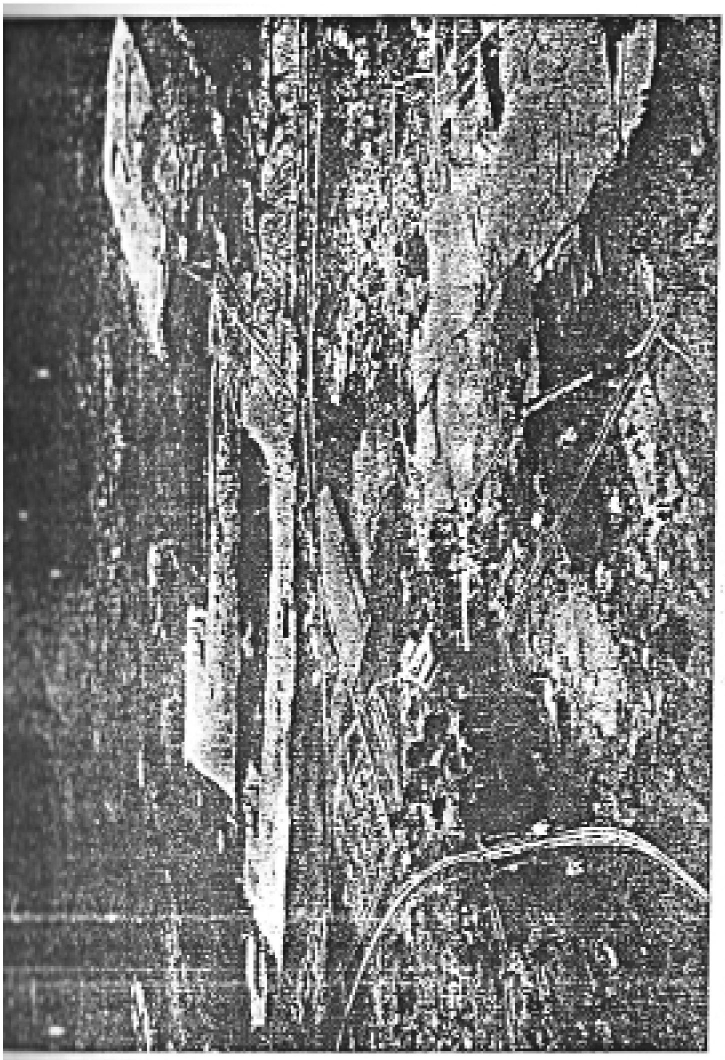
Tin min.ing at the present day may be divided into the following categories:-

Dredging,
Gravel-pump mining,
Hydraulicing,
Open-cast mining,
Alluvial shafting,
Lode mining,
Dulang or Panning.

Dredging

The bucket dredge used in Malaya is of the endless chain type. A continuous chain of manganese steel buckets is carried on rollers resting on a steel ladder, the upper end of which is pivoted on a superstructure some 25 to

30 feet above the deck of the pontoon. The .lower end of the ladder is suspended by cables which pass to a winch over a top and bottom set of sheaves, so that it may be raised or lowered.

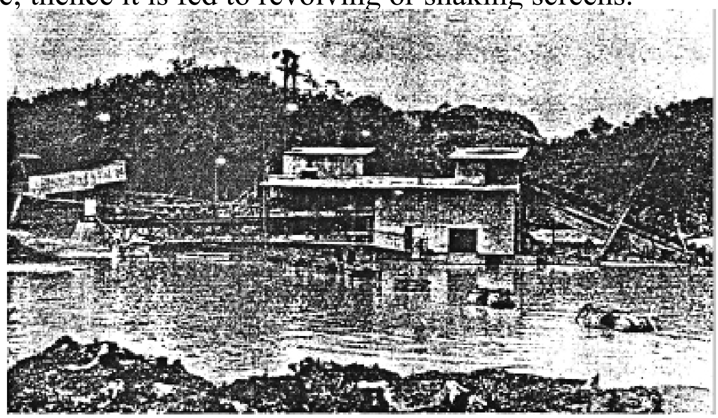


AERIAL VIEW OF PART OF THE TAIPING TIN-DREDGING FIELDS NEAR KAMUNTING.

The buckets pass over tumblers at the upper and bottom ends of the ladder. The raising or lowering of the bottom end of the ladder is part of the operation required to bring the buckets to dig into the working face. The operation must be performed frequently on those properties where the depth of the tin deposits from the paddock-level to bedrock varies considerably with each slight change of location of the dredge.

The top tumblers of all modern dredgers are hexagonal, and bottom tumblers are round. In older dredges, the upper tumbler may sometimes be pentagonal or square and the lower tumbler hexagonal, pentagonal or square. The power to drive the bucket line is applied at the upper tumbler through gears.

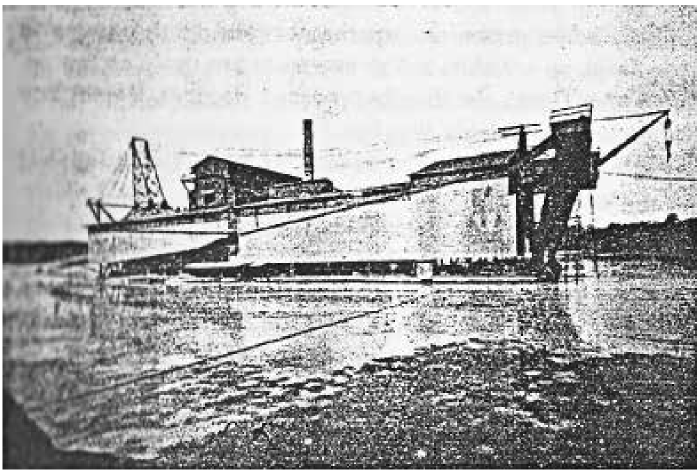
The ground is excavated by the buckets, and every cant of the top tumbler delivers a bucket of dirt into the hopper or drop chute; thence it is fed to revolving or shaking screens.



SPUD DREDGE WITH STACKER.

Jets of water break it up, and anything unable to pass through the screens travels into the "stone chute" and is rejected. The tin bearing material passes through the screens into a distributor which feeds it, with added water, either into jigs or into a series of sluices, in which the tin ore is concentrated.

The dredge floats in an artificially-made pond, termed paddock, dug by the dredge as it progresses. Water flows into the paddock from in front and escapes at the back, carrying with it an amount of slime which varies with the nature of the ground being dredged. Ground with a high proportion of clay is a much less profitable dredging pro- position than sandy material with anequal content of tin ore, because it is a slower process to separate the tin concentrates, and so less ground can be treated in a given time. Dams to retain tailings are built behind the dredge. The usual method of manoeuvring and holding a dredge in position against the working face is by means of wire cables; in one dredge only, “spuds” are used. Usually, the dredge is pulled up against the face by a headline, one end of which is attached to a winch on the dredge, the other being anchored “on shore,” well in front. Side lines, similarly attached to port and starboard, enable the dredge to be moved laterally.



KILLINGHALL DREDGE-THE LARGEST IN MALAYA.

The extension of dredging to ground deeper than had formerly been thought practicable brought new features to dredge design. A few facts may be of interest concerning the introduction of one Malayan dredge that digs to a maximum depth of 130 feet below water-level. It is 195 feet from the centre of the pivot shaft on the ladder to the centre of the bottom tumbler. The weight of the ladder, ladder rollers, caterpillar track, caterpillar-rollers and idlers is 622 tons. The lower tumbler weighs 15 tons, and the buckets, which have a capacity of 12 cubic feet, altogether weigh 197 tons. So the sum of these items alone is 834 tons, which is heavier than the complete weight of the average dredge that works at normal depths.

Until a few years ago, nearly all tin dredges were "straight steam." The boilers were designed to burn either coal or wood, and the main engines were generally of the Marshall horizontal variety, a simple and reliable combination but not necessarily a very economical one.

When other types of power began to threaten the popularity of the steam-driven dredge, designers turned their attention to ways and means whereby both the efficiency and economy of the steam plant could be improved. The latest arrivals use higher boiler pressures, superheaters and triple expansion engines, and, as a result, the power costs are quite as low as, if not lower than, electrically-operated dredges which buy their power from outside supplies.

Dredging has proved most successful in this country. It is cheap, and much ground of low value, which would otherwise have been left untouched, is being worked profitably. Where the bedrock is soft, the whole of the tin-bearing "ground can be excavated, but losses occur when the bedrock consists of limestone pinnacles, because the richest material is contained in inaccessible channels and hollows.

A new dredge under construction for Petaling Tin, Limited, will dig to a maximum depth of 138 feet below water level, the length of the ladder from the centre of the pivot shaft to the centre of the bottom tumbler being 205 feet.

The weight and of the caterpillar track for taking up the slack of the bucket band will be about 800 tons. The lower tumbler will weigh 20 tons and the bucket band, which is of 20 cubic feet capacity, will add another 378 tons; the total weight of ladder, bucket band, etc., will therefore be approximately 1,200 tons.

The top tumbler, which will be installed 52 feet above deck level, will weigh 28 tons, and the total dead weight of the dredge, when in operation, will be about 5,400 tons.

The pontoon will be 304 feet 4 inches long and 72 feet wide and power will be derived from a turbo-electric power station of 1,100k.w. installed on board, which will operate on a steam pressure of 350 lb. per square inch.

One of the distinctive features of the dredge will be the arrangements for dry-conveying overburden or jig tailings to a point 200 feet astern of the dredge, necessitated by the digging depth and by the operating conditions obtaining on the property. Four electrically-driven deep-digging dredges are at present under construction in the Kinta Valley, electric energy to be supplied by the Perak River Hydro-Electric Power Company; All four plants are similar in design, the pontoons being 280 feet long by 70 feet wide by 11 feet 6 inches deep.

The ladders are 211 feet between centres, which will give an effective digging depth of 130 feet below paddock water level. Incorporated in the design is a caterpillar-track idler for supporting the sag of the bucket line, the latter consisting of 135 cast manganese steel close-connected buckets each of 18 cubic feet capacity, the rated digging capacity being 400,000 yards per mensem.

Total weight of ladder complete with rollers and idler is 441½ tons, bottom tumbler 24½ tons, bucket band 341 tons, a total of 807 tons. The top tumbler is of the integral type and weight 21 tons.

The drop chute is designed to either discharge into two screens running parallel to each other, or into an overburden chute placed between the screens to dispose of barren material. The recovery plant consists of "Ruoss" jigs throughout.

An electric dredge of similar design and capacity is under construction at Kamunting but with an effective digging depth of 70 feet, allowance having been made to extend this to 90 feet as and when required.

At the end of 1938 the number of bucket dredges in Malaya was 126, of which 59 were working.

The total issued capital invested in dredging at the end of 1938 was £14,044,051 (Authorised £17,149,043).

The total designed dredging capacity of the 126 dredges per mensem is 22,217,900 cubic yards.

This method of mining produced the following quantities of metallic tin for the years shown;-

Year.		Tons.	Year.		Tons.	
1921	...	4,656	1930	...	23,582	
1922	...	5,353	1931	...	21,951	Restriction of production in force.
1923	...	8,282	1932	...	11,850	
1924	...	9,600	1933	...	10,754	
1925	...	9,070	1934	...	16,835	
1926	...	9,143	1935	...	18,302	
1927	...	12,501	1936	...	30,455	
1928	...	18,752	1937	...	36,157	
1929	...	25,950	1938	...	18,539	

The following table shows the number of dredges in Malaya since 1921:-

1921	...	30	1930	...	105
1922	...	33	1931	...	119
1923	...	40	1932	...	119
1924	...	42	1933	...	120
1925	...	42	1934	...	119
1926	...	50	1935	...	119
1927	...	70	1936	...	120
1928	...	89	1937	...	122
1929	...	105	1938	...	126

The method of mining most popular with the present-day Chinese is by gravel pump. In this method a pressure pump is generally used to feed monitors, which give jets of water powerful enough to cut and disintegrate the ground. The broken material is washed along a channel in the bottom of the mine to a sump. From here the mixture of sand, clay and water is lifted by the gravel pump to the head of a "palong" or flume, which may be anything from 40 feet to 120 feet above the sump.

The heavy tin ore is held up in the "palongs" by stops, or wooden bars, placed one on top of the other at. Intervals across the bottom of the flume; most of the lighter sand and clay passes out of the “palong” with the stream of water, to be deposited in the allotted dumping space. After several days, when the stops in the “palong” have been raised to a certain height, the flow of water and sand from the gravel pump is either shut off, or, more usually, turned into a contiguous and parallel flume. The mixture of tin ore and sand in the flume is then still further concentrated by racking it against a flow of water. ater is introduced at the head of the “palong” and the clean-up continued until the "palong" is empty. The concentrates (50-60 per cent. Sn02) from this operation are placed in wooden buckets and taken to the washing sheds for final treatment.

GRAVEL PUMP ON LEFT AND DE-WATERING PUMP ON RIGHT.

It is rare that a continuous and sufficient supply of water can be obtained for this method of mining unless a reservoir is constructed to receive the overflow from the tailings dam and supplement the limited supply of new water that is available. An advantage of this economy is that the miner is compelled to retain tailings for his own profit instead of merely as a requirement of law.

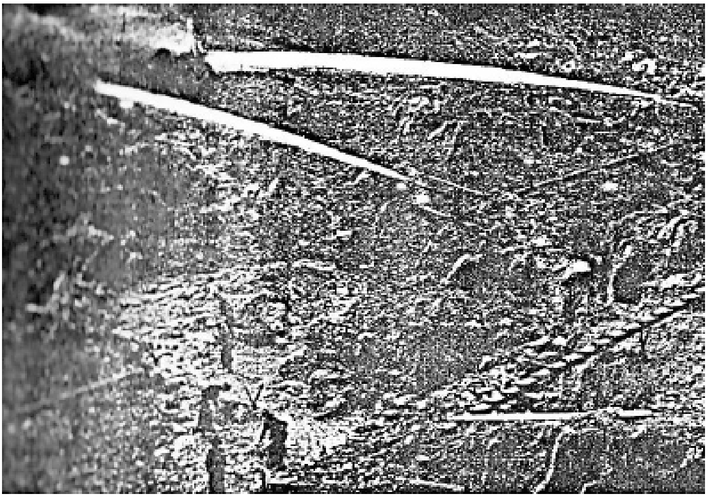
Great ingenuity is shown by the Chinese in disposing of tailings from gravel-pump mines. As the size of the mine increases, a point is reached when the grade of the ditch from the face to the pump reduces the working face to an uneconomical level, and a new mine must be started. A mine, leaving a large area for the retention of tailings, while mining operations can be continued in the smaller part. The sand from the gravel pump is trained along that side of the bund remote from the mine, and thereby helps in its construction.

TWO STAGE GRAVEL PUMP MINE.

There are only one or two mines now working by this once very popular method. Two large pumps are mounted on a pontoon, one for supplying water to monitors, and the other for lifting the resulting gravel, sand and water.

Mining with Pumps on a Pontoon

The machinery necessary for driving these pumps is also installed on the pontoon. The monitor cuts away the ground, and the gravel pump lifts it to the sluice, where it is concentrated. When it is desired to move the pontoon, the paddock is allowed to fill with water, and the pontoon is then floated and so moved with ease to another site. Paddock is then pumped dry. This method has lost its popularity owing to its cost. Its success is largely dependent on there being no great quantity of seepage water to cause expense in pumping. In the majority of cases this form of mining cannot compete with a bucket dredge, which is unaffected in its economical operation by the presence of excess water. A very up-to-date plant of the pontoon type is working successfully at Rawang, and another at Malim Nawar.



A CHINESE HYDRAULIC MINE.

Hyraulicing with Water Under Natural Feed

A dam is constructed in a suitable position in a steam bed as such an elevation as may be necessary to produce the required volume and pressure of water at the level of the mine. The impounded water is then conveyed, either by pipes direct or in ditch line to a pressure box, whence it flows down pipes to the mine. The water under a pressure dependent on the height of the pressure box above the mine, emerges from a monitor which resembles a fireman's nozzle on a large scale. The jet is directed at the face of t he mine, cuts it down, and the resulting mixture flows down a a ditch or a wooden sluice. Here the tin ore is partially concentrated by the flow of water, and women, using a round, shallow, wooden dish, called "dulang" are employed to continue the concentration.

In cases where the ground to be worked lies below the drainage level of the district, or lacks sufficient grade, elevators are employed. These appliances supply the want of fall by elevating the disintegrated ground and water to a higher level, where

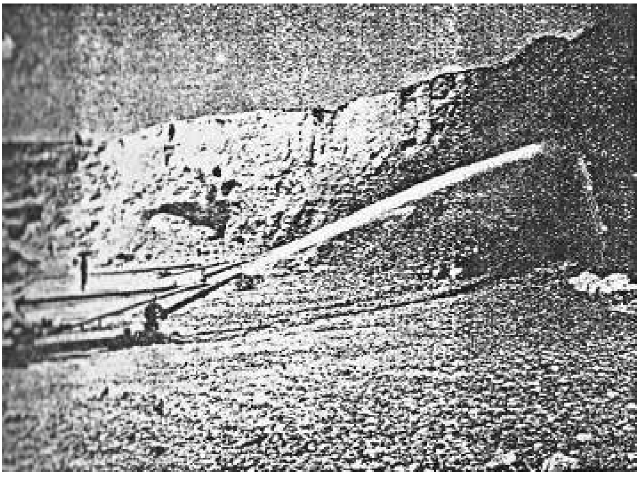
PIPE LINE CONVEYING WATER TO MINE.

the necessary slope can be given to the sluice. A jet of water, under pressure, sucks in water and gravel and forces them up a pipe, delivering them at the sluice-head, which is placed above, as already described, at a height sufficient to give the required slope.

The Societe Francaise des Mines d 'Etain de Tekkah (usually known as French Tekkah) were the pioneers in using water power for the generation of electricity to drive their gravel pumps and also using the same water under natural head for breaking the ground for the gravel pumps. This company baa two hydro-electric power stations in the hills beyond Gopeng. At the upper one the water is taken from the River Guroh at an altitude of

2,200 feet. From here it is conducted to the power station by a 32-inch pipe line with a head of 735 feet. The power generated is 2,100 k.w.

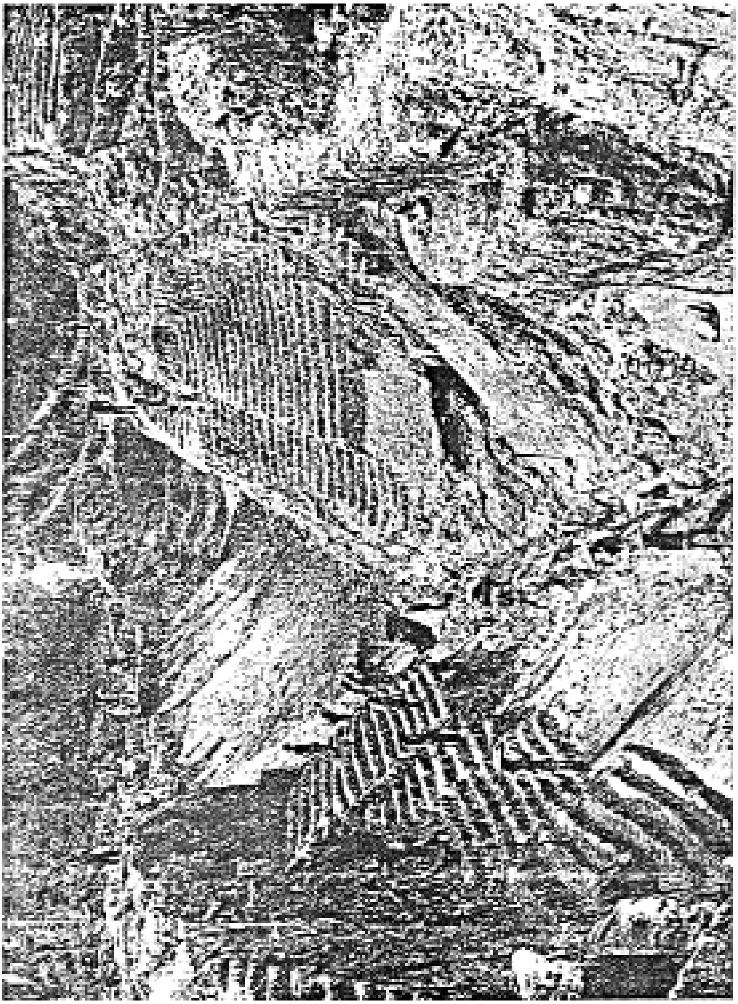
On leaving the turbines of this No. 1 power station the water is again conducted by pipe line to No. 2 power station with a head of 300 feet. The power generated is 1,050 k.w.



HIGH PRESSURE MONITORS

On leaving the turbines of No. 2 power station the water is taken by pipe lines twelve miles long to the mines where monitors operating at pressures varying from 90 lbs. to 120 lbs. per square inch break the ground to be fed to the electrically-driven gravel pumps. The water is thus used three times before being discarded.

A new vertical type of electrically-driven gravel pump has been developed on this mine which gives increased running time and greater efficiency, amounting to as much as 20 per cent. Various sizes of these pumps are in use ranging from 3 horse-power to 180 horse-power and their cost is about half that of the ordinary horizontal type. The smaller units are extremely useful in working the rich deposits of tin ore in the deep pockets in the



TYPICAL EXAMPLE OF A "LAMPAN."

limestone bottom where normal methods arc very difficult owing to the restricted nature of the pockets which are sometimes not more than 10 to 15 feet in diameter.

T he quantities of water used, and the pressure obtained, vary very considerably, from installations using only 100 cubic feet a minute, under a pressure of 50 lbs. per square inch to the big pipe line of Gopeng Consolidated and Kinta Tin Mines, which carries 6,000 cubic-feet of water a minute abd producesa pressure of 170 Ibs. per square inch on the mine. The size of nozzles used varies from I inch diameter to 3 inches. The power produced by the larger sized monitors, working under high pressures, is considerable, and the ground is cut extremely quickly by them. A 3-inch nozzle, working pressure of 170 lbs. per square inch, has potential energy of about 340 horse-power at the nozzle. Compared with some installations in America, however, these figures are small. There, 11-inch nozzles are used, working under a pressure of 430 lbs. per square inch, which develop 15,000 horse-power per jet.

Hyraulicing with Water Not Under Pressure

Hydraulicing with water not under pressure is known locally as "Lampan" mining. Water is led along a ditch at the foot of the mine face, which is then cut into steps by men who work downwards, starting from the top. •When the bottom of the face is reached they work upwards, cutting the steps away. The ground so barred down• falls into the ditch, where much of the sand is washed away by the water, and a concentrate remains from which the tin ore is extracted. A variation of the method is to lead the water over the top of the face, using it as an agent for breaking up the ground.

It will be realised that hydraulicing produces large quantities of waste materials, known as "tailings", the proper retention of which is a matter of anxiety both to the Government and to the miners. In certain cases much expense is incurred. Where no great volume of flood water is to be allowed for, or where there is no natural stream to contend with, the problem resolves itself into the construction of suitable impounding earthworks and masonry spillways, so designed as to take the maximum estimated flow of water. The spillways should be capable of being raised quickly and easily.

Hydraulicing in hilly ground presents a problem of tailings retention, which has never been satisfactorily solved. In past years, great damage has been caused from such workings. The town of Kuala Kubu lies under a vast expanse of sand, owing to flooding which started prior to the year 1911. In places, buildings have entirely disappeared, while in others only roofs are visible. It has been necessary to build an entirely new town on a site several miles away. Hydraulicing in hills has been stopped by the Government, except in two localities in Pahang.

Open-cast Mines with Trucks and Rails

Some enormous excavations have been made by mining with truck and rails. The old mine of the Sungei Besi Mines, Limited, is 3,000 feet long, 1,200 feet wide, with, a depth of about 125 feet, representing 16,000,000 cubic yards, all cut by hand labour using the ”changkol” (a form of hoe).

A new mine was opened up in 1929, a little to the north, and it is from here that most of the tin ore is obtained at present. It is now 2,100 feet long, 900 feet wide, with a depth of 75 feet. From this mine 1,802,000 cubic yards of overburden and 2,050,000 cubic yards of “Karang" have been excavated. A Ransome Napier electric navvy has done the excavating. In both mines the broken ground is loaded into small trucks which run over light rails, and are hauled by electric power up an incline to the surface, where their contents are dumped into puddlers. After being thoroughly stirred up, the pulp passes to jigs, where it is subjected to a pulsating action, which concentrates the tin-ore and allows the sands and slimes to flow to the tailings-flume.

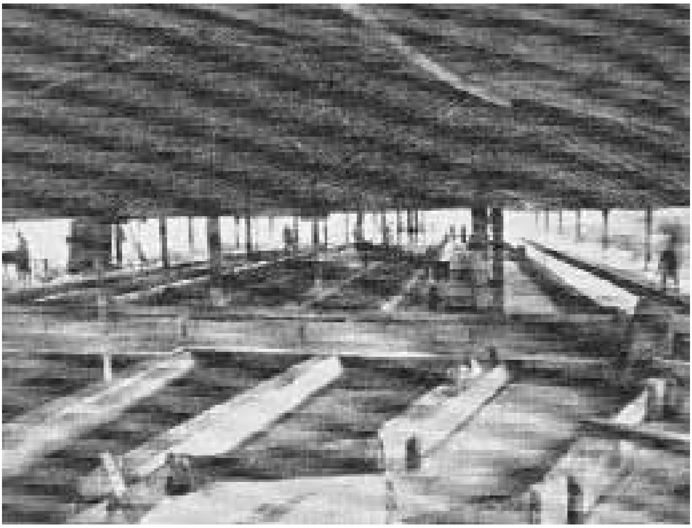
The mine was once the site of the old village of Sungci Besi. Some years ago, shafts were found in the floors of the houses, from which the Chinese were stealing rich tin ore; this led to prospecting the area and the opening of the new mine.

Hong Fatt (Sungei Besi) Limited, operate a mine similar to those belonging to Sungei Besi Mines, Limited, except that it is much deeper. The area at the surface is 115½ acres and at the bottom of the mine-which is 310 feet from road level-3¾ acres. From this huge excavation, roughly 30,000,000 cubic yards of earth have been removed. The mine pumping height is 340 feet. Four Ruston Bucyrus electric navvies are used for excavation on the upper benches of the mine, but hand labour is still employed at the mine bottom.

RUSTON BUCYRUS EXCAVATOR IN HONG FATT MINE.

The broken ground is loaded into small trucks and hauled up to puddlers, as at Sungei Besi Mines, Limited, but instead of being treated by jigs, it is then passed over sluices where the ore is concentrated.

In most open-cast mines the "karang" or tin-bearing sand, is overlain by a depth of overburden, non-payable ground, which varies from a few feet to as much as 60 feet. This is removed by trucks on rails and dumped well away from the mine, so that it shall not interfere with present and future developmcnt. The (faces of the mine should be worked in a series of benches, separated by sloped races of 10 to 20 feet. Lines of rails run along



CONCENTRATING SLUICE BOXES, HONG FATT MINE

MAIN HAULAGE INCLINE - HONG FATT MINES

the benches to the different haulage inclines, one set leading to the puddling and dressing plant, and the other to the overburden dump. The original laying out of a large open-cast mine presents an engineering problem of 110 mean order, and any miscalculation in the first instance may result in difficult and costly works when development reaches an advanced stage.

SMALL CHINESE CHAIN PUMP WORKED BY TREADMILL.

Open-cast Mining by Hand Labour Only

Open-cast mining by band labour is a purely Chinese method. The ground is put into flat baskets, which are hung at either end of a pole, and so carried on the shoulders of the coolies up to a notched log to the surface. This is admirably shown in the illustration on the front coyer, which was made by Mrs. Hamerton, of Haytor Estate, Ka par. Some years ago, mines of this type were dewatered by means of an ingenious chain pump, made wood in which boards set at right angles to a wooden chain, lie, close-fitting in a wooden trough, fixed with its base in the sump and its upper end high enough for the water to flow away. On revolving the chain, either by tread-mill or water-wheel, the mine water is brought to the surface.

Until recently, in most mines, a portable steam engine or oil engine was used in conjunction with a centrifugal pump to dewater the mine, but, of late years, electric power has been replacing other forms of power. Electric power is supplied by the Perak Hydro-Electric Power Company, Limited, and by the Government-owned Kuala Lumpur Power Station.

CHINESE CHAIN-PUMP WORKED BY WATER-WHEEL

The "karang" from these mines, having been brought to the surface, is first puddled by hand in a square pit, and then carried to the cleaning sluices, called "landchutes". These are coffin-shaped boxes. Water is let into the head of the box, and the "karang" is shovelled in by a coolie at the side. Another coolie stands in the water raking the concentrates with a "changkol" (a kind of hoe), while other labourers, men or women, dig out the waste material and carry it away.

CHINESE FOOT-PUMP.

Alluvial Shafting

Alluvial shafting was very popular twenty-five years ago but the method has now been almost abandoned because it is a wasteful means of extracting tin ore from the ground, and one not encouraged by officers of the Mining Department. It was usually practised where the "pay-dirt" occurred as a thin bed overlain by a much greater thickness of overburden. In some cases, shafts reached depths of 200 feet; some were small circular pits, just large enough to allow the miner to squat at the bottom; others were double compartment shafts, properly timbered. Where the workings were shallow, the procedure was to sink shafts about 30 feet apart to reach the pay dirt and then to remove to whole bed, supporting the roof of the excavations that occupied the spaces between shaft bottoms by means of round jungle timbers. Artificial ventilation was rarely employed and then only in the form of a wind-chute. Water was removed by buckets and a winch, or, if it occurred in any quantity, by a pulsometer pump.

It is a common sight, nowadays to see old underground workings of this type exposed in the faces of open-cast and gravel-pump mines. The richest ground has been removed, but what remains, although unprofitable at the time when underground mining was in progress, is highly remunerative in response to modern methods.

Lode Mining - Pahang Consolidated Company Ltd.

The mines operated by the Pahang Consolidated Company, Limited, combine to form one of the largest producers of tin ore in the world. They are situated at Sungei Lembing, in the north-east of the State of Pahang, in the watershed of the Kuantan River, about 26 miles from the east coast of the Peninsula. The Company hold a concession of more than 150,000 acres, but the lodemincs are all close together, near to a comparatively small outcrop of granite.

Sea communication is via Kuantan, and a daily river service is maintained by the Company between that port and Pasir Kemudi, a distance of 28 miles. From Pasir Kemudi, the Company's light railway connects with the mine, a further distance of 15 miles. Formerly there was no road communication between the mine and Kuantan, but a great change has been effected during the last few years; except for a few miles by motor launch, the whole journey can be done by car, to be completed in two hours instead of the ten to fifteen hours of the past.

The mines were originally worked by Chinese, and nothing was attempted below water level. Europeans first started mining in 1887, and have worked there continually since that time. The present Company was reconstructed in 1906, and the capital was increased to £475,000 in 1913.

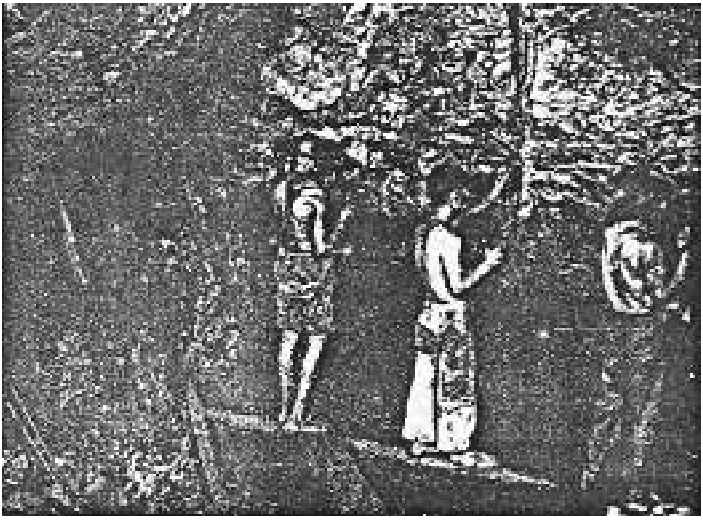
The lodes are located within an area approximately 6 miles north and south, and 21 miles east and west, in hilly country, ranging from. 120 feet to 1,150 feet above mean sea level. Prospecting has located no important alluvial deposits, although, as is usual, the lodes were originally discovered by following up alluvial in the creeks.

The tin bearing lodes radiate from the eastern side of a granite intrusion into the overlying shale, schist, quartzite and sandstone; some occur also in the granite itself. They strike cast and west and dip either north or. south, whilst the pitch of the ore shoots in the lodes is roughly parallel in the contact of the granite with the schist.

The ore bodies have no well-defined walls, and consist generally of narrow-filled fissures, with varying widths of impregnated country on either side. In some cases, the ore body is in the nature of a stockwork. In addition to cassiterite, the lodes carry iron pyrites, zinc blende, copper pyrites and arsenical pyrites. No wolfram occurs, and galena. Only occasionally Tourmaline in the lodes is uncommon.

Owing to the hilly nature of the terrain, much mining has been possible above adit level, and the outcrops of most lodes have been worked by open-cut. Several lodes have been worked below adit level to depths of about 500 feet, and in the Willinks and Myah Mines, a series of ore bodies has been opened down to a depth of 1,200 feet below adit, and for a distance of nearly two miles along their strike. These same lodes have been mined to 1,000 feet above adit. Level, so their vertical extent has now been proved as 2,200 feet. A detailed geological survey of this part of Pahang has been commenced, and a wealth of information will be available after the many miles of underground workings still accessible at the Pahang Consolidated Mine have been examined. It is suggested that this will give real assistance in the search for payable lode tin deposits, both at this mine and elsewhere.

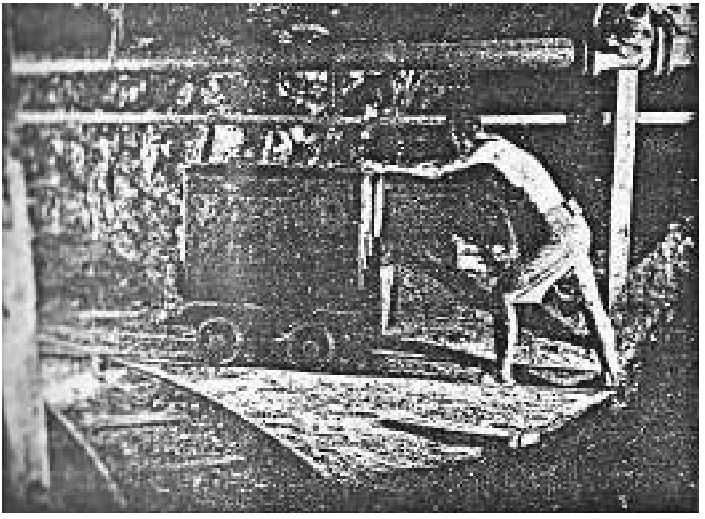
The Willinks and Myah Mines have been developed through two vertical shafts, with upper levels 60 feet apart and lower levels 100 feet apart. Owing to the erratic nature of the ore shoots in the lodes, frequent cross• cutting is essential. The lodes vary in width from a few inches to as much as 60 feet, the individual are bodies tending to a lenticular shape and following one another en echelon: The more usual stoping width is from 4 feet to 8 feet. Stoping is by the shrinkage method, or the “cut and fill” method, depending on the nature of the ground. Electric battery locomotives and Diesel locomotives with filtered exhausts are used for transport underground.



HAND DRILLING IN STOPE.

Ore is treated in a centrally-situated mill, where the battery consists of 50 head of Californian stamps, each of 1,240 lbs falling weight, 4 head of Holman air-cushion stamps, and a conical type ball-mill; the total capacity is more than 800 tons per day. Prior to being crushed, the ore is washed free of clay and sand on shaking screens, after which it is reduced to a. suitable size by jaw crushers followed by a. conical crusher, and conveyed by belt to the battery bins. The battery crushes to pass a screen of eight meshes to the linear inch, and the pulp is classified into three products, which are distributed as follows:-

Coarse to jigs,
Sands to James sand tables,
Slimes to James slime tables.



TRUCKER UNDERGROUND

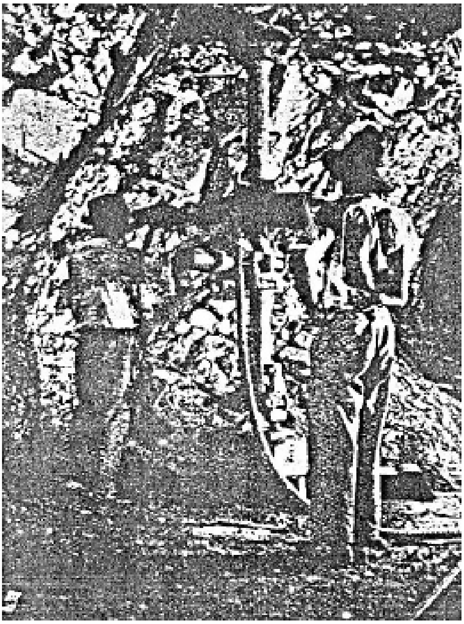
.

The “heads” from all are calcined in an Edwards roasting furnace, the “middlings” go to Wheeler pans for regrinding and subsequent reclassification; the" tailings" arc then rejected.

The roasted concentrates are then ground in Wheeler pans, and after classification, are passed over James retreatment tables. The products are treated on the dressing floor, and then when necessary, are leached with hot sulphuric acid to remove the last traces of copper. The “black tin" (tin ore) is then dried and bagged for shipment to the smelters at Singapore. It assays about 73 per cent metal.

Copper can be recovered from the discharge from the leaching vats by deposition on iron scrap; arsenic is deposited in the roasting furnace flues.

The central power station is situated at Sungei Lembing, near the Willinks Mine, and consists of six Diesel-engine generating sets, aggregating 6,200 horse-power, each of the three larger units being 1,500 horse-power. Usually only three of these engines are needed.



ROCK-DRILL MINERS.

There are also eight steam boilers aggregating 1,515 nominal horse-power. Sixty per cent of the electrical energy generated is used .for pumping water from the Willinks and Myah Mines.

Four air-compressors, two of 2,500 cubic feet free air per minute, one of 1,000 cubic feet, and another, a stand-by, of 1,200 cubic feet per minute, are used to supply compressed air to the underground hoists and rock-drills. Electric current, generated at 550 volts, 50 •cycles, 3 phase, is transmitted underground at 6,600 volts to the main pumps at the 1,100 feet level in the

Willinks Mine, and then stepped down to 550 volts. The cost of electrical generation is 0.39 pence per kilowatt hour.

This pumping station consists of six centrifugal pumps, five of 350 horse-power, each capable of lifting 600 gallons of water per minute direct to Bells Adit, a height of 1,285 feet, and one of 155 horse-power with capacity 250 gallons per minute. About I,650 gallons of water per minute arc pumped continuously for which three pumps are adequate, the others being ready as stand~bys in case of a sudden inflow of water or breakdown of plant. In addition; a pump of the Cornish type is available.

Supplies of firewood and timber, adequate for all purposes, both underground and on surface, are obtained from the surrounding jungle by means of light railways. The mines have well •equipped mechanical and electrical workshops, where all running repairs can be effected. The foundry services all ordinary castings and such material as mine tracks and rolling stock for the light railroad. Indeed the mines are practically independent of any outside engineering concerns in the country.

When the mines are in full production, employment is given to over 3,000 persons. All the miners and most of the artisans are Chinese; several hundred Malays are employed as engine drivers and attendants.

Lodes in Selangor

In the last quarter of a century, more than 60,000 tons of "black tin" have been produced from these lode-mines; they show promise of continuing as large producers for many years. Lodes are known in the Main Range of granite mountains that divides Pahang from Selangor. Near Sangka Dua and Peretak, the country includes coarse porphyritic granite, granite of medium grain size, granite porphyry and aplite, which have suffered faulting and fracturing. The fissures so formed have been filled by an extensive series of extensive vertical parallel stringers varying generally from eighth-of-an-inch to 3 inches in width, and separated by barren country. Where two zones of mineralization have met, the result has been enrichment, with ore bodies 3 feet to 12 feet wide, such as have been seen at the Ulu Kol Tin Mines, at mines on Gunong Bakau and at the Ying Sai Mine, Peretak.

A CHINESE DULANG WOMAN.

There has been extensive mineralization, but, unfortunately, this is coupled in most areas with a lack of concentration of the tin ore, which will form the main obstacle to successful commercial exploitation. In this connection, it is well to emphasize that the continual improvement in mining methods must enable ore-deposits of increasingly lower grade to be successfully treated.

Practically all the known ore bodies were discovered, incidentally, by the removal of overburden during the course of ground-sluicing operations at the t.ime when this form of mining was permitted, and it is most probable that others still remain to be found in many parts of the Main Range.

Dulang washing or panning is a method extensively employed for winning tin ore in many parts of the country. This work is done by women, some being employed by miners to concentrate the ore in the sluices, while others work on their own in streams and rivers. The method is simple, but requires some skill. A shallow wooden dish about 30 inches in diameter and 3½ inches deep in the centre is dug into the sand of the sluice or stream bed, and quantity of sand and water is thus put into the dish. This is now subjected to a peculiar motion, more or less of the nature known as vanning, by means of which the waste material is washed over the edge and the ore remains. It is arduous work in the heat of the day, entailing as it does continual standing in water with the back bent. Those women employed in the large hydraulic mines are, however, sheltered by a roof. Tin ore, to the extent shown below, was sold by licensed "dulang women, working individually, during the years from 1928 to 1938.

"Dulang" or Panning

TIN ORE WON BY LICENSED DULANG WOMEN.

	Pikuls.
1928	26,114
1929	23,423
1930	21,395
1931	31,470
1932	21,602
1933	16,350
1934	16,915
1935	19,381
1936	22,852
1937	22,363
1938	22,897

It must be remembered that since March, 1931, the Control Scheme, an account o f which occurs at the end of this pamphlet has been in operation, and the output from panning has been curtailed by law.

Total Prduction of Tin

The following figures will convey some idea of the amounts of ore won by the various methods described, and the part Malaya 'has taken in supplying the world's needs.

EXPORTS •OF TIN FROM FEDERATED MALAY STATES, SHOWING PERCENTAGES OF WORLD'S OUTPUT.

Year.	Output in tons.	Percentage.	Year.	Output in tons.	Percentage.
1900	43,111	54·0	1920	34,934	28·6
1901	47,475	51·1	1921	34,490	30·4
1902	47,258	53·3	1922	35,286	27·1
1903	50,842	54·1	1923	37,649	29·9
1904	51,733	54·1	1924	44,043	33·0
1905	50,991	51·6	1925	45,926	32·0
1906	48,617	47·4	1926	45,947	32·5
1907	48,429	47·7	1927	52,179	33·4
1908	50,835	46·8	1928	61,935	35·5
1909	48,743	42·2	1929	67,041	35·0
1910	43,862	37·7	1930	62,063	36·5
1911	44,148	37·7	*1931	53,457	36·6
1912	48,420	38·6	*1932	28,363	30·6
1913	50,126	37·5	*1933	23,924	26·3
1914	49,042	39·6	*1934	32,671	28·4
1915	46,766	36·6	*1935	40,780	27·7
1916	43,870	34·8	*1936	64,719	35·9
1917	39,833	30·7	*1937	75,393	36·3
1918	37,370	30·1	*1938	41,079	27·7
1919	36,934	30·5			

* Restriction in force.

The world's output of tin has increased considerably since 1914, owing to Bolivia and Nigeria entering the field as big producers. Of more recent years Thailand and the Belgian Congo have joined the ranks. In studying the outputs given hereunder, it must be borne in mind that, since 1931, Nigeria and Bolivia have been subject to very drastic restriction as members of the Control Agreement and Thailand has been limited to approximately the output of 1929. The terms on which the Congo became a. participant are such as have allowed for the expansion of her tin industry.

ANNUAL TONNAGE OF TIN METAL.

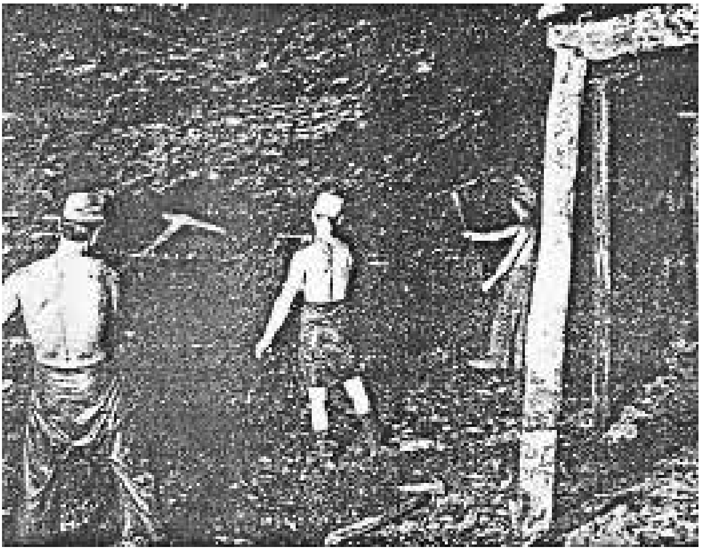
Year.	Bolivia.	Nigeria.	Belgian Congo.	Thailand.
1914	22,002	4,300	44	6,591
1915	21,450	4,837	—	8,998
1916	20,811	5,731	94	8,765
1917	27,418	5,820	106	9,154
1918	28,818	5,904	106	8,835
1919	26,956	5,718	158	8,325
1920	29,075	5,167	396	6,201
1921	28,500	5,067	631	6,150
1922	27,685	5,123	893	6,979
1923	30,636	5,860	945	7,624
1924	31,553	6,200	985	7,952
1925	32,224	6,256	1,098	7,862
1926	30,061	7,417	1,147	6,978
1927	35,808	8,056	877	7,435
1928	41,404	9,129	782	7,527
1929	46,338	10,734	1,011	9,939
1930	38,146	8,569	840	11,060
1931	30,742	7,772	188	12,447
1932	20,583	4,263	677	9,261
1933	14,725	3,762	2.225	10,324
1934	20,634	4,996	4,602	10,537
1935	27,168	7,029	6,481	9,779
1936	24,074	9,634	7,310	12,678
1937	25,024	10,468	8,856	16,494
1938	25,371	7,305	7,316	13,520

Uses of Tin

Tin is used in the manufacture of tinplate and terneplate, of alloys such as bronzes, gun metal, fusible alloys, babbit metal and other similar "bearing" alloys, type- metal and pewter, of tinfoil, collapsible tubes and block tin articles. In addition, compounds of tin are used in dyeing and calico printing, and the chloride is used for weighting silk before dyeing.

COAL MINING

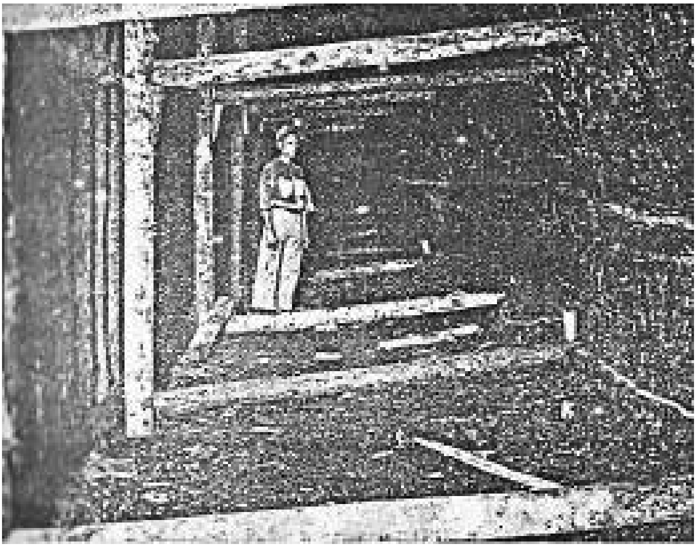
Coal is now being mined in Tertiary beds at Batu Arang, in Selangor, 25 miles distant from Kuala Lumpur. The coal has a pitch black colour and breaks with a conchoidal fracture. It is fairly hard, and has a specific gravity of 1•2-1•3. It burns with a long flame. An unfortunate characteristic, however, is its tendency to spontaneous combustion. It is non-coking coal.



COAL HEWING ON LONG WALL COAL FACE.

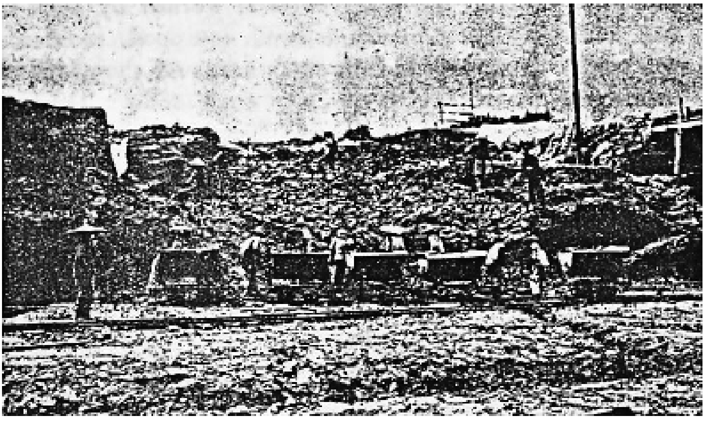
There are two seams, divided by 100 feet of strata, the net thickness of the top seam being 40 feet and that of the bottom 25 feet. The seams dip at approximately 14º and are worked by inclines, from which levels are set off at approximately 200 feet intervals. The coal between each pair of levels is worked by long• wall methods. To minimize the possibility of spontaneous combustion, and to ensure very ‘ nearly complete extraction of the unusually thick seams, sand filling is practised on a large scale, every cubic yard of coal extracted from other than permanent roads and ways being replaced by a cubic yard of sand. Where the seams outcrop the coal has been worked by open-cast with success. The Colliery is well equipped, mechanical methods being employed in all cases where such show improvement upon labour.

The total production of the Colliery, from its inception to the end of 1938, has been approximately 9,000,000 tons. Th peak annual production was reached in 1929, with 661,500 tons, since when the lowest point reached was 234,000 tons in 1933, the

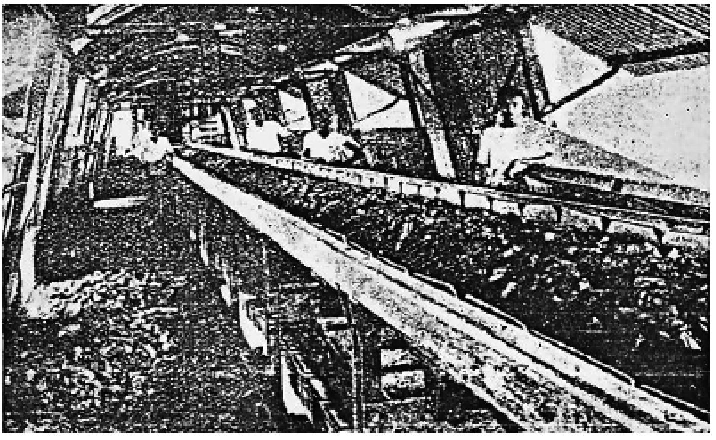


LONG WALL STOWAGE BARRICADE.

renewed upward tendency being marked by a production of 377,441 tons during 1935. The whole of the coal produced is consumed in Malaya; it proved a godsend to consumers of power during the Great War, when foreign coal was either unobtainable or procurable only at a prohibitive cost. The Company controls some 8,000 acres, a large part of which is underlain by both seams. There are very large reserves of which some 10,000,000 tons are developed, and readily available for extraction.



COAL WINNING IN OPEN-CAST WORKING.



PICKING BELT AT COAL WASHERY.

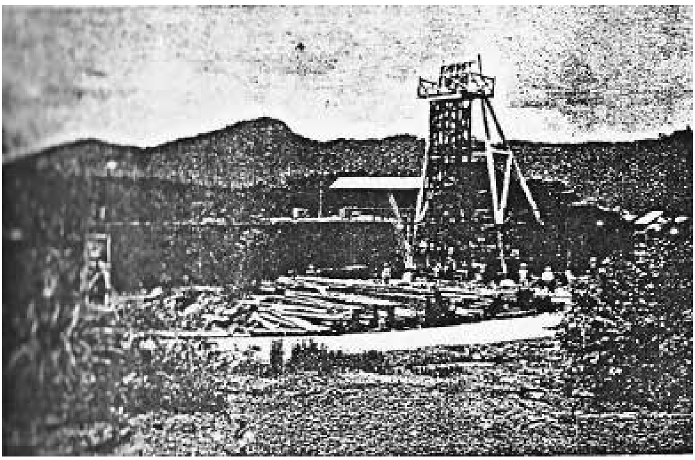
GOLD MINING

Gold is now mined on an extensive scale only in the Raub Australian Gold Mining Company's concession. The Raub gold-

Raub

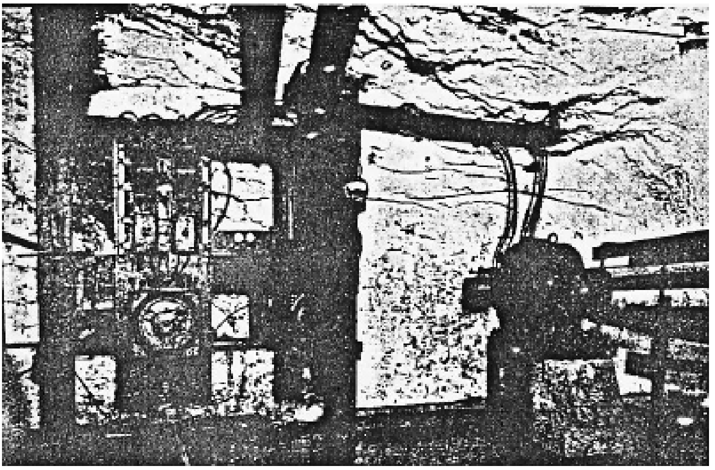
deposits consist of a series of lenticular ore-shoots located in steeply dipping lode-channels occupied by quartz and brecciated shale. They form the payable sections of an extensive rock-system in highly-folded and aulted calcareous slates, and are part of the gold-belt which runs along the eastern side of the main watershed of the Peninsula into Thailand.

During the last fifty years, seven hundred thousand ounces of gold have been produced at this mine, and the main workings have reached a depth of 1,100 feet. The gold content of the payable ore-shoots varies between 4 dwt. and 30 dwt. per ton.

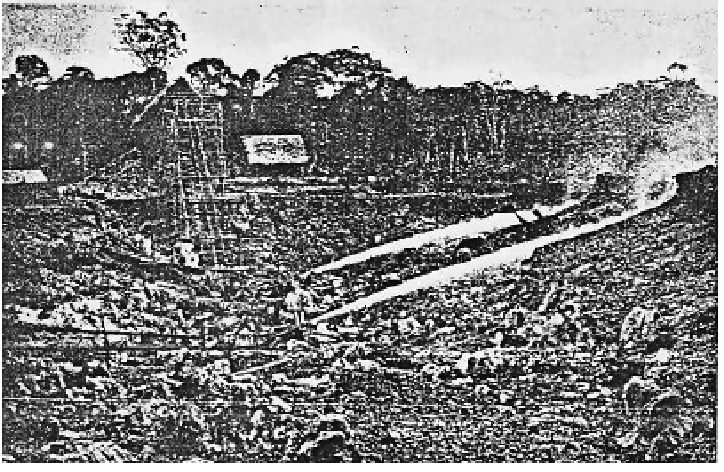


**RAUB AUSTRALIAN GOLD MINING CO.
BUKIT KOMAN SHAFT.**

"Cut and fill" and open stoping are employed, and the ore is lifted by electrically-operated hoists. Hydro-electric power is supplied by the Sempan Power Plant, 8 miles distant, capable of developing 850 kilowatts with a pressure head of 310 feet. Power is generated at 5,000 volts, transformed up to 10,000 volt for transmission, and stepped down to 230 volts for use by the machines at the mine. Compressed air is supplied by two Bellis-Morcom 2-stage compressors, each delivering 1,000 cubic feet per minute at 90 lbs. pressure; they are driven by 200 horse-power motors. The ore is treated by jaw-breakers, stamp and cyanide plant.



THREE•THROW PUMP INSTALLED AT No.7 LEVEL (640 FEET BELOW SURFACE).

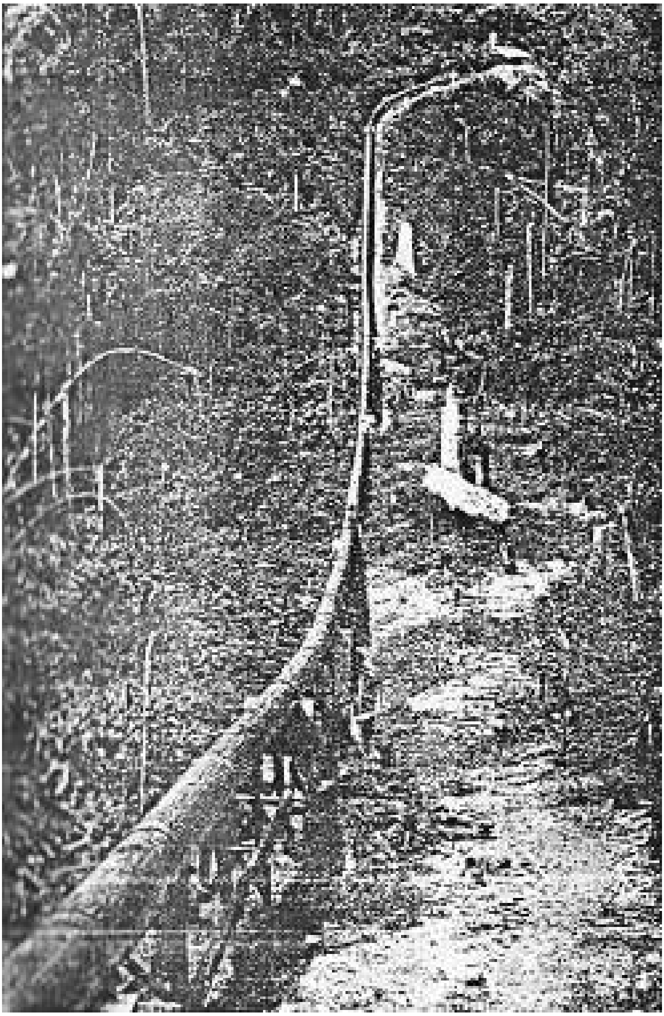


HYDRAULIC GOLD MINE

More alluvial gold is produced from the Batang Padang district of Perak than anywhere else in Malaya.

Alluvial Gold Mining

The majority of the gold mines in this district, being producers of tin ore as well as of gold,



PIPE LINE TO GOLD MINE.

the method adopted for the extraction of a concentrate is, in the The soft nature of the bedrock, usually phyllite or black schist, renders it necessary to clean up the bottom of the mine, because, unless this were done much of the gold. Would remain there and never reach the gravel pump. This cleaning up is done by Chi-

The soft nature of the bedrock, usually phyllite or black schist, renders it necessary to clean up the bottom of the mine, because, unless this were done much of the gold. Would remain there and never reach the gravel pump. This cleaning up is done by Chinese women with dulangs, and the concentrate of tin ore and gold thus obtained is added to that won from the palong.

The cleaning up is done at intervals of from five to ten days, the procedure varying on different mines, and when all the concentrate seems to have been removed from the palong, the interstices between the planks are thoroughly brushed to ensure complete extraction of all the precious grains. Once a ‘month, the feeder palong also is cleaned up, yielding a concentrate that is chiefly gold. This feeder palong is paved with wood blocks.

In the dressing-shed the tin-gold concentrate is treated on a 30-mesh screen. The oversize is washed on a very shallow dulang and the coarse gold separated from the tin ore. The through size is also washed in the same way. The tin ore thus obtained is placed in tubs and mercury is added to amalgamate with the gold it still contains. After mixing thoroughly, it is washed in a flat dulang to separate the amalgam from the tin ore.

The amalgam is squeezed in a cloth, and most of the Mercury comes through and is recovered. The remaining amalgam is heated to drive off the mercury and leave the gold, which is then sold.

The usual fineness of this gold is about 820. Gold sold by the Ban Hin Gold l\lines, Limited, who do their own smelting, has a fineness of about 935.

WOLFRAM AND SCHEELITE MINING.

Wolfram

In the past there was a useful production of wolfram from Kedah and Trengganu, with small quantities from a mine near Tapah in Perak, and from Titi in Negri Sembilan. In spite of the better demand in recent years, Malayan annual exports in 1936, 1937 and 1938 have amounted to only 285 tons, 269 tons and 373 tons; the insignificance of this production should not be taken to prove that there are only small deposits of wolfram, but that the mineral occurs comparatively rarely in alluvial deposits, because it is less resistant to water action than cassiterite. Malaya is a difficult country to prospect for lodes, because the cover of soil and vegetation is abnormally thick, but any increased production of tin ore from lodes will probably be accompanied also by an increase in that of wolfram, for it is likely that successful prospecting for tin lodes will be accompanied by the discovery also of lodes containing wolfram. This applies particularly in Trengganu, Kedah and Negri Sembilan. There is no wolfram in the tin lodes mined by the Pahang Consolidated Company, Limited, at Sungei Lembing.

Mining the famous deposit at Kramat Pulai near Ipoh, Perak, ceased in 1939. This ore had resulted from the replacement of a mass of crystalline limestone lying under hard crystalline schist; acid tungsten bearing solutions rich in fluorine had emanated from granite and passed along fissures to limestone which had thereupon been changed to become fluorite containing scheelite. As the bulk of the solutions had become imprisoned under an impervious schist roof, complete replacement of a great mass of limestone occupying an anticlinal fold had taken place. Along the crest of the fold, to a depth of 100 feet below the schist, only an occasional block of limestone remained unreplaced but, further down, mining operations passed from ore into granite and limestone.

Scheelite

An extensive programme of diamond drilling revealed the size and shape of the deposit and enabled a scheme of underground mining to be evolved and successfully carried to completion, but it failed to trace any considerable extensions of the ore nor were any new deposits discovered, although favourable geological structure was evident in several places.

Much difficulty was experienced in drilling through the crystalline schist, the component folia of which were being ground contained rock• layers of different hardnesses. Great care had to be exercised to avoid trouble caused by diamonds breaking from the crown.

There are other occurrences of scheelite along• the granite-limestone contact in East Kinta, and, in the first half of the year 1930, ten tons of saleable ore were milled from lumps of fluorite-scheelite ore embedded in residued clay in a mine a few miles south of Kramat Pulai. Here the same type of crystalline schist also occurs, and it remains to be seen whether drill holes can be driven through it to explore below.

Exports of scheelite from Malaya during 1936, 1937 and 1938 were 1,364 tons, 836 tons and 282 tons.

IRON-ORE MINING.

Batu Pahat, Johore

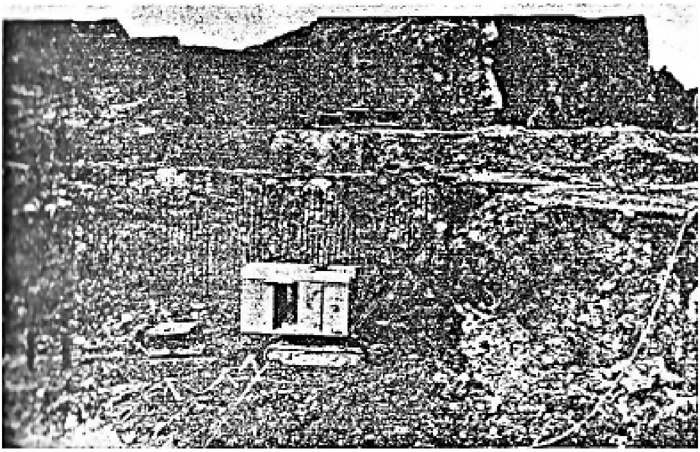
The Ishihara Sangyo Koshi, Limited, has been mining •iron ore at Sri Medan, Batu Pahat, Johore, since 1921. The deposit resembles a mushroom in shape, and occurs in a hill estimated as having been approximately 200 feet above the level of the surrounding plain before mining commenced. The country enclosing that portion of the ore body, which lies 20 feet above the plain, appears to be a structureless reddish clay, but, below this, the country is volcanic breccia which. has been intensely kaolinized.

The iron ore occurs in the form of haematite, and bulk assays show that shipments contain approximately 60 per cent. of metallic iron. Phosphorus and silica are present in small quantities in depth, but these impurities have not yet penalized the marketing of the o=e.

Mining of the ore body is carried on by quarrying, in benches varying in width from 40 feet to 100 feet, at intervals of 20 feet vertically. Overburden is excavated by two mechanical shovels, loaded into trucks and transported to a dumping ground. The iron ore is broken down by blasting, holes being drilled into the ore body by Ingersoll Rand drifters. It is loaded into trucks by hand and pushed to the endless-rope haulage, which conveys them to “tongkangs” lying at the wharf side. A considerable amount of boulder iron ore is found on the extremities of the deposit. The iron ore is not treated -before shipment. Electric power is generated on the mine by a Diesel plant.

The outputs for the last three years have been as follows, in long tons:-

1936.	1937.	1938.
590,288	519,339	549,960



ELECTRIC SHOVEL EXCAVATING OVERBURDEN.

Most of the ore above water-level has now been removed, and it is fortunate that bauxite deposits have been discovered on the property which can be mined and exported by the existing equipment and organization.

In Trengganu there are two Japanese companies mining iron ore, the Nippon Mining Company at Dungun and the Ishihara Sangyo Koshi, Limited, at Machang Sa.'tahun, Kemaman.

Trengganu

The Nippon Mining Company have been mining at Dungun since 1930. The iron ore, haematite, occurs near the contact of granite with shale and sandstone. It outcrops at many places on the hill known as Bukit Besi and also as a boulder deposit on the lower slopes of the hill; So far only the latter deposits have been worked. The method of mining is by open-cast benching, using endless incline haulages to take the ore to the

Dungun

washing plant or to the large reinforced concrete ore-bins. Ore trains are run from the bin. to the loading jetties at Nibong, on the Dungun River, and to Sura, on the Coast, a distance ‘of about 18 miles. From the loading jetties tongkangs are towed by tugs to steamers lying outside Dungun harbour; bad weather makes loading impossible for three months during the north-east monsoon period.

The labour force totals 4,810, the majority of whom are Indians; there are several hundreds of Chinese and Malays. The following are the outputs:-

1931	...	162,969 tons.	1935	...	682,217 tons.
1932	...	213,556 ,,	1936	...	1,027,066 ,,
1933	...	383,273 ,,	1937	...	1,147,204 ,,
1934	...	492,484 ,,	1938	...	585,690 ,,

Machang Sa’tahun

The Ishihara Sangyo Koshi, Limited has been mining iron ore at Machang Sa’tahun, near Kemaman, since 1928, manganese ore since 1925 and tin ore since 1939; the life of the iron mine is now estimated at rather more than two years.

At the “Iron Mine” high grade ore, haematite, is found in the form of a pipe in sandstone and shale, the granite being not far distant; at the boundary of this ore body a lode containing tin ore has been found. Active prospecting of the tin lode, both by surface and by underground methods, is in progress; while the full extent has yet to be determined, yet a considerable amount of ore containing tin in economic quantity has already been proved. The various ores are mined, necessitating a carefully controlled method of selective mining and, in the case of tin, the construction of a special treatment plant. Mining is carried out by a combination of open-cast benching and underground “glory hold” methods; ore bins and, where necessary, small washing plants are installed on the various levels to assist in the sorting of the different types and grades of ore. Mixed tin and iron ore is treated in a small tin dressing mill of orthodox layout except that a magnetic separator is required to separate the tinstone from the final con centrate; a product containing over 73 per cent. of metallic tin is obtained. Transport is by rail to Sungei Pinang, where it is loaded into tongkangs, and taken to Kuala Kemaman for shipment to Japan in the Company's own steamers. This Company also operates a gravel pump tin mine at Suugei Timah, farther up the valley from Machang Sa'tahun. The total labour force in 1938 was as follows:-

Japanese	49
Malays	373
Chinese	359
Indians	231

The following are the outputs of iron are since 1928:-

1928 ...	25,928 tons.	1934 ...	152,836 tons.
1929 ...	55,692 ,,	1935 ...	170,277 ,,
1930 ...	65,712 ,,	1936 ...	153,296 ,,
1931 ...	58,557 ,,	1937 ...	101,203 ,,
1932 ...	43,417 ,,	1938 ...	98,546 ,,
1933 ...	79,533 ,,		

The total production of iron are from Trengganu for the year 1938 was 905,316 tons.

The mining of iron ore has recently begun also in Kelantan. The Temangan Iron Mine, situated one and a half miles from the railway in Kelantan, is owned by the Southern Mine Company, Limited, with head office In Tokyo.

The ore is mainly limonite, hydrated ferric oxide, containing approximately 54 per cent iron, and occurring as blocks in yellow and red clay-capping hills to a depth of 12 to 20 feet. It has resulted from the decomposition of mica schist slate and shale, accompanied by the concentration in the soil of their iron content.

The ore is carried in trucks to bins which feed an aerial ropeway passing from the mine to the railway at Bukit Besi. From here it is taken along the Federated Malay States Railway 36 miles to Palekbang, und thence in Lighters down the

Kelantan River to steamers which transport it to Japan.

Production began in May, 1937, and exports have been 49,223 tons in 1937 and 159,900 tons in 1938. The Company has estimated its reserves at 6 million tons. As with other mines situated near the east coast of Malaya, shipments must end in October because of the monsoon, and cannot be resumed until the following April.

MANGANESE-ORE MINING.

Manganese ore is mined in Trengganu and in Kelantan. In Trengganu it is mined by the Ishihara Sangyo Koshi, Limited, Machang in conjunction with their iron mine at Machang Sa'tahun, near Kemaman. The manganese ore, pyrolusite, occurs as a well defined and nearly vertical lode, the lower portion deteriorating into mixed wad and clay; the lode has been worked for a vertical height of 250 feet. The method of mining is by open-cast benching along the strike of the ore body; the ore is loaded into trucks and is transported with the iron ore to Sungei Pinang and from there tongkangs take it to steamers lying off Kuala Kemaman. The following are the outputs:-

1925	...	4,689	tons.	1932	...	9,228	tons.
1926	...	45,510	,,	1933	...	10,299	,,
1927	...	48,555	,,	1934	...	9,681	,,
1928	...	48,852	,,	1935	...	17,412	,,
1929	...	32,183	,,	1936	...	26,761	,,
1930	...	20,696	,,	1937	...	23,126	,,
1931	...	8,848	,,	1938	...	23,054	,,

The Company export direct to Japan in their own steamers.

Garu Manganese Mine

The Bukit Tandok manganese deposit near the Gual Priok railway station, Kelantan, mined by the Nippon Mining Company has been practically worked out after having yielded about 50,000 tons of manganese ore, and the Garu deposit, a few miles away, estimated to contain about 20,0000 tons is now being mined. The ore deposits are cappings on hills formed through weathering of the bedrock and concentration at the surface of its manganese content.

Their mode of formation is like that of limonite. At Tandok where the original rock was probably slate or slaty shale, the principal ore was psilomelane; pyrolusite wad and limonite were also present; at Garu, pyrolusite is as important as psilomelane because the original rock was largely quartzite. Quantities exported during 1936, 1937 and 1938 were 10,006 tons, 9,667 tons and 8,916 tons. The ore occurs both as largely hard masses, several feet across and also as tiny pebbly concretions in the soil. The kidney-shaped appearance of some of the ore is characteristic. It is often cellular in texture and contains various oxides of iron as impurities.

The method of mining is by quarrying. Much of the ore needs only to be broken up and is then ready for transport. The pebbly concretions are extracted from the soil by sieving, and the fines are washed with water in shallow troughs.

The Company has a light railway, eight miles long, from the mine to the railway station at Gual Priok, whence the ore is conveyed 17 miles on the Federated Malay States Railway to lighters at Turnpat, which, in turn, deliver their contents to ocean-going steamers. These steamers have been partly filled with haematite and magnetite at Dungun, in Trengganu, and can only operate from March till the middle of November. During the remaining periods of the year, the north-east monsoon prevents their approach to the coast.

TRANSPORT.

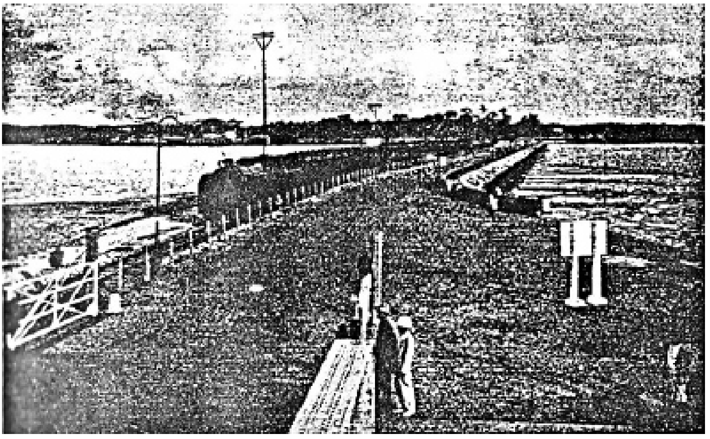
The 1,068 miles of metre-gauge railway provide Malaya with cheap and efficient transport, all the principal mining areas and centers of agriculture being connected through it to the ports. The main line runs up the west side of the Peninsula, a distance of 480 miles, from Singapore to Prai, where a frequent ferry service connects with the island seaport, Penang. Bukit Mertajam is a. railway junction 6½ miles from Prai, and from and from here a branch runs northwards to Padang Besar, the furthest Malayan station of this main line, 580 miles from Singapore. Here it joins the Royal State Railways of Thailand. Another line runs north-east, from the main line at Gemas, 137 miles north of Singapore, to Tumpat in Kelantan, 465 miles from Singapore; it also connects with the Thai railway system, by means of a short branch line from Pasir Mas, 16 miles south of Tumpat, which extends to Sungei Golok railway station on the boundary between Thailand and Kelantan.

Other branches connect the main line with the west coast ports of Malacca, Port Dickson, Port Swettenham, Teluk Anson, Port Weld, and with the coalfield of Batu Arang. All ports, with the exception of Malacca, are owned and worked by the Federated Malay States Railways. Port Swettenham and Prai have up-to-date facilities for handling every class of cargo, including heavy machinery, and they possess ample warehouse accommodation. The Federated Malay States Railways maintain collection and delivery services at more than 100 stations, and provide door-to-door service for all descriptions of traffic.

Where the amount of traffic warrants, private sidings are constructed by the railway to serve mines and estates, in return for an annual maintenance charge; in certain circumstances, the charge is refunded from freight payments, and traders who forward or receive a considerable quantity of traffic thus obtain the use of a siding free.

Goods are conveyed at the rates shown in tables on pages 83 to 122 of the Railway Tariff Book No. 9 Part II, but many special rates are in operation, particulars of which can be obtained from the Railway Administration, who is always pleased to advise on transport problems and to quote inclusive rates for all descriptions of traffic. Examples of rates for varying distances applicable to machinery of all kinds, tin and tin ore, coal, firewood, fuel oil, and other mining necessities, is given on page 81 of this pamphlet. Special vehicles, up to 36 tons capacity are available for the conveyance of unusually heavy machinery.

Through daily and nightly expresses run between Singapore and Kuala Lumpur, Kuala Lumpur and Prai, and twice weekly express services are provided between Prai and Bangkok and Singapore and Tumpat. These trains fitted with electric fans, are furnished with dining cars and sleeping accommodation including bedding.



AN EXPRESS PASSENGER TRAIN PASSING OVER THE JOHORE CAUSEWAYFROM SINGAPORE.

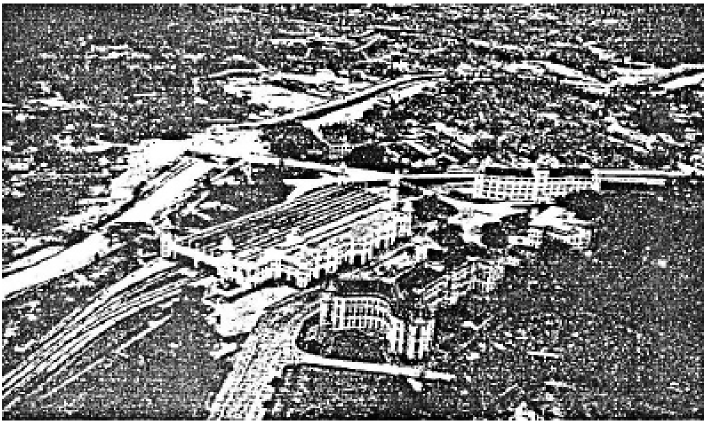
Air-conditioned first class coaches are attached to the day mail trains between Prai-Kuala Lumpur and Singapore-Kuala Lumpur, and first class air-conditioned sleeping carriages are attached to the night mail trains between Singapore and Kuala Lumpur. Passenger fares per mile are:-

First class ...	...	$6\frac{1}{4}$ Straits cents	= 1·75 pence.
Second class ...	...	3 ,, ,,	= ·84 ,,
Third class ...	...	2 ,, ,,	= ·56 ,,

Each passenger is allowed free conveyance of luggage to the extent given below:-

First class ...	...	...	100 katis	= $133\frac{1}{3}$ lbs.
Second class	...	...	60 ,,	= 80 ,,
Third class ...	...	...	40 ,,	= $53\frac{1}{3}$,,

In addition to the fares shown above, there are many facilities for cheap travel, such as season tickets, week-end tickets, special fares for ocean travellers making the journey between Penang and Singapore and from Port Swettenham to Penang and Singapore or vice versa, mileage coupon books, and reduced fares for large parties.



AN AERIAL VIEW OF RAILWAY STATION AND OFFICES, KUALA LUMPUR.

Other passenger traffic in the country is now catered for almost entirely by motor cars and motor buses. Rickshaws are used in the towns, and gharries are still to be seen in some outlying places. The individual gets about in his car, on a motor cycle with or without a side-car, on a push bicycle, or, where these means are not available, on foot.

About 8,600 miles of metalled roads connect all the more important mining centres to the ports. In addition, there are about 1,335 miles of unmetalled roads, and about 2,000 miles of bridle-tracks and paths.

In certain places, where the conditions call for it, elephants and oxen are used for the transport of supplies and machinery to mining sites. The average load for an elephant is about 800 lbs., depending on the bulk of the packages. Where beasts

TRANSPORT OF TIN ORE ON RAFTS.

TRANSPORTING PIPES BY ELEPHANTS.

of burden are not obtainable, and going is heavy, all supplies are carried by bearers, Chinese men or women who are capable of dealing with as much as 150 lbs but the average load is about 100 lbs. Some of these bearers are capable of achieving great speed.

During the last decade, nearly every Chinese mine-owner has made a road to his mine to enable him to reach it in comfort .in a car, and also to facilitate the lorry transport of tin ore and supplies. In July, 1939, the retail price of petrol was 75 cents per gallon, equivalent to 1s 9d (1 shilling and 9 pence), the figure at which it had been sold for several years; it is obtainable in every village and town. Motor cars with their drivers can be hired at 20 cents (about 5½ pence) a mile. Most of the mines in the Federated Malay States can be reached in comfort by car.

For jungle work that entails camping, Malay carriers are paid from 50 to 70 cents per day, 1s. 2d. to 1s. 7½d.

LABOUR_

The mainstay of the mining industry and of many other industries in this country is the Chinese coolie. He did most of the work under the old primitive conditions and is equally essential now that more modern methods are in vogue. He is extremely industrious, and is prepared, if need be, to work the whole day to obtain what he considers necessary to meet his requirements. On the other hand, if he is working for himself and has made enough he is disinclined to do any more work that day. He very seldom gives any trouble, and on the whole, is most tractable and obedient. In times of high prices and much profit, he takes what he can get; but when the slump comes, his ideas come down with it, and he carries on in a most admirable way. If a Chinese mine-owner can convince his labourers that his mine has lost money; they are often willing, with very little demur, to accept as little as 20 per cent. of their normal wages.

The various clans of Chinese that come to Malaya include Cantonese, Hakkas or Khehs, Hokkiens, Teochews, Kwangsais and Hylams. Work by shafting is almost entirely confined to Hakkas or Khehs. Hylams usually work as domestic servants, but become miners or rubber planters when the occasion seems profitable. Hokkiens supply most of the shopkeepers. There are now very few Teochews engaged in mining. In 1938, there were

(This is referred to on page 78)

DISTANCES AS FROM FORWARDING STATION.	Lowest Rate. (Class 15.)		Highest Rate. (Class 1.)		Machinery of all kinds. (Class 5.)		Machinery when in lots of not less than 50 pikuls. (Class 6.)		Tin and Tin Ore. (Class 8.)		Coal and Firewood in consignments of not less than 120 pikuls. (Class 15.)		Fuel Oil. (Class 10.)		Fuel Oil in consignments of not less than 100 pikuls. (Class 11.)		Fuel Oil in consignments of not less than 120 pikuls in Tank Waggons. (Class 12.)	
	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.	Per Pikul Mile.	Per Ton Mile.
	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.	Cts.	Pence.
50 Miles	0·26	1·22	1·88	8·75	0·96	4·52	0·70	3·29	0·70	3·29	0·26	1·22	0·64	3·01	0·52	2·45	0·42	1·96
100 "	0·20	0·94	1·69	7·05	0·86	4·05	0·55	2·59	0·55	2·59	0·20	0·94	0·48	2·26	0·40	1·88	0·34	1·60
150 "	0·16	0·75	1·27	5·09	0·65	3·07	0·43	2·01	0·43	2·01	0·16	0·75	0·36	1·69	0·31	1·44	0·27	1·28
200 "	0·14	0·66	1·03	4·82	0·53	2·47	0·36	1·69	0·36	1·69	0·14	0·66	0·31	1·44	0·27	1·25	0·24	1·11
300 "	0·12	0·56	0·75	3·53	0·40	1·88	0·29	1·36	0·29	1·36	0·12	0·56	0·25	1·16	0·22	1·04	0·20	0·94
400 "	0·11	0·52	0·61	2·88	0·34	1·59	0·26	1·20	0·26	1·20	0·11	0·52	0·22	1·02	0·20	0·93	0·18	0·86

Two shillings and fourpence = one Straits dollar.

EXAMPLES OF F.M.S. RAILWAYS GOODS RATES ON VARIOUS COMMODITIES FOR SPECIFIED DISTANCES ltogether 45,704 Chinese employed as miners, and 9,600 "dulang" women, the latter mostly of the redoubtable Kheh clan.

Chinese miners are seen at their best when dealing with water, with which they are exceedingly clever. They are capable of bringing it from any distance by ditches or bamboo pipes, and of distributing it without any survey, except of the order of what they would call "look-see." They also show to great advantage in open-cast working and "Iampan." Underground they are admirable. Their houses in large mines are airy, clean, and tidily kept. The "dulang" women have a very hard life, standing in water all day washing for tin ore and it is no casual thing to see a woman at work with a baby strapped on her back. In the evening they cut firewood, cook the food, and do the housework.

Recruiting is done in China, and coolies arrive and depart according to the demand. Indentured labour was abolished in 1914. The Chinese coolie is employed in one of three ways, working either for a daily wage, or by contract, or on what is called the tribute system. The wage is from 40 to 60 cents a day, equivalent to 11.2d to 16.8d, and he is housed and fed free, at an additional cost to the employer of about 20 cents a day, equivalent to 5.6d. He must supply his own clothes, but not his tools. The working hours are usually eight, with extra payment for overtime.

The contract labourer is under a contractor who receives, as a general rule, from $5 to $7 (l1s. 8d. to 16s. 4d.) for each "chang" or 50 cubic yards of ground cut and carried away. The tribute labourer usually forms one of a gang who has their supplies advanced by a mining speculator, and share all profits that are left after the lessor has had his tribute paid to him. The head of the gang and any foremen receive a slightly larger share than the rest.

On the large mines, the coolies lodge comfortably in big roomy "kongsi" houses made of poles, with "attap" walls and roof. Attaps are usually made from the leaf of the nipah palm, each frond of which is cut off and bent over a stick, others being added until the stick is full. The ends of fronds are tied, making a kind of board of leaves. These are placed one on top of the other, starting from the bottom of the roof, each stick about 2 inches above its lower neighbour. The whole is kept in place by strips of bamboo, to make a perfectly watertight roof for a year or two, after which it begins to give way to the destructive climate. Inside, the building will have an office where the accounts are kept, a store for the tools and tin ore and a simple kitchen, containing fireplaces under enormous iron dishes in which the rice is boiled. A small shop to provide simple needs, such as matches and tobacco, may be included. The remainder of the house is "dormitory" for the coolies. The beds consist of planks laid on a framework about 2½ feet high. Mosquito curtains are invariably used and grass mats, but there are no mattresses. At the head of each bed are the coolie's personal belongings in a. box, and he uses a blanket, usually a red one. Pillows take the curious, and, one would have thought, most uncomfortable form of a lump of wood, a box-shaped piece of earthenware or a rattan •framework covered with black oil cloth. The pillow is placed under the head about the level of the ear, so that, while the head is supported, there is a space under the nape of the neck. Evidently it is cooler than if a soft cushion were used .

The coolies' staple food is rice, prepared according to the custom of their clan. The majority boil the rice with very little water, and eat it in a dry condition, but for their midday meal the Hokkiens and Teoehews prefer the watery gruel that is obtained by boiling a little rice in a lot of water. In addition to rice, a meal includes vegetables, and sometimes meat or fish, the latter either fresh or dried. The amount and frequency of these depends on the prosperity or otherwise of the industry. As a rule, three meals a day are taken, the first at dawn, the second at 10.30 a.m. and the third about 5 p.m. Tea without sugar or milk is the staple drink, but a thirsty man likes water. Very few Chinese mining coolies have their wives with them. As a rule their female relations remain in China, and the coolies are very good in remitting money for their sustenance. Certain Chinese firms arrange to forward these remittances for a small charge, and the undertaking is carried out so satisfactorily that there are few, if any, complaints.

The above description applies to the bigger and more flourishing mines. When conditions reach the stage of a struggle for a bare existence, the coolies, now working as tributers, live in hovels made of any material that is handy, such as old kerosene tins beaten out, or jungle leaves. In all circumstances, however, their neatness and cleanliness are remarkable.

Malays seldom live on the mines, but have their houses elsewhere, generally on their own piece of land. A typical Malay house is raised on wooden posts a few feet above the ground, and is approached by a ladder. The floor is usually of large bamboo, split and hammered out flat after the joints or nodes have been removed. The walls are either “attap” or the same flattened bamboo interwoven. A :Malay’s food consists of rice as a staple, with curry added. meat, fruit and vegetables also are eaten.

The Malay does not, as a rule, indulge in mining himself, being generally content to hold the land and sublease the mining rights to a Chinese. There are, however, certain functions in mining which Malay fulfils admirably, such as electrical work, surveying, and engine driving, looking after pipe lines and working hydraulic monitors. The women are largely employed in concentrating the ore by “dulangs” in the big sluice-boxes, and in their bright sarongs are a very attractive sight.

The following table gives the census of Malays employed in mining during the last seven years:-

1932 ...	... 1,745	1936 ...	... 4,123
1933 ...	... 1,865	1937 ...	... 3,964
1934 ...	... 2,584	1938 ...	... 3,943
1935 ...	... 2,967		

Indians

Of natives of India, South Indians such as Tamils, Telegus and Malayalis predominate. They are very good at moving earth, which they carry in baskets on their heads, unlike the Chinese, who always use baskets slung at either end of a pole balanced on their shoulders. Some of them make very fair engine drivers.

The other races of India are grouped together, irrespective of their origin, as "Bengalis", though most of them come from the Punjab. So far as actual miming is concerned they do but little, but can shift ground with considerable efficiency if occasion arises. The majority are employed as bullock cart drivers. The following table gives the census of all Indians employed in miming for the last seven years:-

1932	3,775	1936	9,019
1933	3,684	1937	11,803
1934	6,659	1938	7,425
1935	6,586		

Recruiting in India is under Government control and an assessment per labourer is charged, the money going to a fund for assisting immigration to Malaya.

Other Eastern Races

Of other eastern races there are very few. Occasionally Japanese, Thais and Sakais are found mining, but their numbers only amount to a very small percentage of the total.

Western Races

Western races are represented in the Malayan tin-mining Industry by British (both home and overseas), French in some number, and Americans. The number of Europeans actively engaged in miming since 1913 is shown in the accompanying table:-

1913	195	1929	670
1919	225	1930	571
1920	274	1931	405
1921	327	1932	303
1922	297	1933	290
1923	303	1934	361
1924	344	1935	386
1925	415	1936	498
1926	471	1937	544
1927	519	1938	453
1928	625		

The type of machinery employed for mining in the Federated Malay States varies considerably, according to the nature of the country in which it is used. For example, where open-cast mining is carried out in virgin country, some distance away from a township, the power is usually obtained from loco-portable steam boilers, although they have high fuel consumption, and their power is limited. It would be difficult and expensive to install plant of greater power, and the abundant supplies of cheap firewood obtainable from the surrounding jungle completely nullify the other disadvantage.

Internal combustion engines are much favoured by the Chinese, the power of the units varying from 100 to 200 horse-power, which is a convenient range for mining by gravel pump. Gas engines are but little used, because of the inconvenience of generating gas from charcoal, coal or wood, for each small power plant, and because the much handier oil engine is also more economical.

The Diesel engine has maintained its popularity, and, for most purposes, the most suitable size is from 200 to 300 horse-power per set. There are some companies using many such engines with a total horse-power of 2,000; it is found that such a scheme of individual power units caters more efficiently for the ever-present factor of fluctuating output than a single engine with a stand-by.

Steam driven dredges now employ water-tube boilers of the Babcock & Wilcox type, sometimes fitted with chain-grate stokers. Their steam capacity ranges from 5,000 to 10,000 lbs. per hour. Great care is now taken to ensure economical working, and some of the boiler equipment is quite up to date. While machinery on mines worked by Chinese has altered very little in the last decade, yet considerable development has taken place in mines owned by European companies, including, of course, those operated by dredges.

There are dredges now working to a depth exceeding 130 feet, and others which have a capacity of 250,000 to 350,000 cubic yards per month. Such monsters are specially designed for the particular conditions under which they have to work and elaborate precautions are taken to ensure careful manipulation of the spoil gathered, and to obtain the maximum of tin concentrates. The machinery necessary to attain these objects is expensive, so much so, that the cost of some modem dredges is in the neighbourhood of £225,000.

The Perak River Hydro-Electric Power Company, Limited, now supply many mines in the Kinta Valley with power derived from their 27,000 kilowatt hydro-electric station at Chenderoh, situated on the Perak River. Stand-by steam stations at Malim Nawar and Batu Gajah have a capacity of 24.500 kilowatts and 12,500 kilowatts respectively.

The aggregate motor load from mines, connected to the Kuala Lumpur supply system, at the end of the year 1938, was 19,838 horse-power. The price at which electrical power is supplied compares favourably with the cost of maintaining small internal combustion engine units, and has proved an attractive proposition to the Chinese miner. Within the next year or two, most of the mines situated in the zone served by these schemes will be using their power. Several dredging companies are• already large consumers of energy from these sources.

TOTAL EFFECTIVE HORSE-POWER - MINES IN THE F.M.S.

F.M.S.	1936.	1937.	1938.
Steam	30,810	35,905	20,252
Steam-electric ...	11,221	6,692¼	7,564
Hydraulic	19,577	20,321	22,763
Hydro-electric ...	15,364	16,183	12,083
Suction Gas ...	373	484	135
Oil Engines ...	65,102	106.440	66,327
Oil-electric ...	16,903	19.112	15,334
Electric Motors ...	73,791	87,891½	78,690
Petrol Motors ...	63½	96	239
Landchutes ...	50	—	—
Total	233,346½	293,124¾	223,389

At the Rahman Hydraulic Mine, wire rope-ways are used for conveying ore to the mill. In smaller mines in mountainous country the Chinese use a primitive type of rope-way for lowering their ore-bearing ground from the hills to the valley below. It consists of a pair of heavy wires, strung taut between the workings and the mill, and a light rope which passes round a pulley on the top. The full baskets, slung on one wire, are tied to the upper end of the rope, and by their fall, pull up the empty ones. Where distances and heights are great, a number of sets or stages may be installed in series.

Fuel

Wood, coal and oil are all used as fuel. Firewood may be obtainable from the forest surrounding the mine. As already sta. ted, its former predominance as a fuel has gone for ever, and it now only finds a use to generate steam in small loco-portable boilers which are still the best power unit for opening up mines in jungle country.

Coal is the fuel most used in large power stations and on steam-driven dredges. It is mined at Batu Arang, in Selangor by the Malayan Collieries, Limited, and goes by the name of Rawang coal; it is not a high-grade coal, being rather soft and friable, but gives good results when burnt under suitable conditions. The calorific value is 8,500 to 9,500 British Thermal Units.

Oil fuel is used on mines throughout the country, and 76,425 tons were consumed during 1938. It is in the form of Diesel fuel oil, for internal combustion engines; little or no oil fuel is burnt in boilers. The supply companies have storage installations in all townships and villages, and roads leading to the mines allow easy transport in bulk direct to the power plants.

The approximate prices ruling during the year 1938 for coal, oil fuel and wood were respectively:-

Coal	\$9•00 per ton.
Oil Fuel	\$39.00 per ton ex tank at Kuala Lumpur or Port Swettenham.
Wood	\$3.50 to \$4, 00 per ton of 50 cubic feet.

LEGISLATION AND ACQUISITION OF MINING LAND.

The method by which mining land can be acquired in the Federated Malay States is described hereunder, but it must be remembered that a restrictive alienation policy is in force at present. Land may be acquired for mining in any of the following ways;-

(i) By purchase from the lessee;

(ii) By applying for and obtaining a prospecting licence, and subsequently selecting an area for a lease;

iii) By direct application to the Government for a lease.

Applications under (ii) and (iii) made through the Land Office.

There are two types of prospecting licences, one which confers a right to a lease, and the other, simply a permit to bore, with no right of selection. The minimum fee for a prospecting licence is $100.

An application for a mining lease must show the position of the land, with sufficient details to enable the land officer to locate it and have it surveyed. At the same time, a cash deposit must be made. If the application is approved by the British Resident, the land is surveyed, and a lease is issued. If the applicant wishes to commence mining operations without delay, or before a survey can be completed, a mining certificate may be issued, to be surrendered on completion of the lease. Premium is charged for the lease at rates from $10 (£1. 3s. 4d.) per acre upwards.

A mining lease conveys the following rights;-

I) The right to work and win all minerals de scribed in the lease and to dispose of them.

II) The right to put such buildings on the land as may be necessary, and to grow, such vegetables and keep such live stock as may be required for the labour force.

(III) The exclusive right to use all jungle produce found on the land, but such produce must not be removed beyond its boundaries.

The following is a brief summary of the conditions by which the lease is governed:-

(i) Rent must be paid. It is usually $1 (2s. 4d.) an acre per annum.

(ii) Boundaries must be kept open.

(iii) Work must start within six months of the date of issue of the lease.

(iv) Within a further six months the requisite number of labourers must be employed, usually one man per acre; power producing machinery is allowed for at the rate of eight men per horse-power.

(v) There must not be a lapse of more than twelve months from these labour conditions.

(vi) The lessee may be required to work any lodes on his land.

(vii) Mining operations must be carried out in an orderly, skilful and workmanlike manner. .

(viii) Government officers shall have free access to the land.

(ix) Such notices as are required shall be posted in a conspicuous place.

(x) Material such as stone and gravel, if required for a public purpose, may be removed by the State without payment.

(xi) Correct account books must be kept.

(xii) Reasonable access to adjoining land must be allowed.

(xiii) Precautions shall be taken to ensure the safety of all labour employed on the land.

A breach of conditions number (i), (iii), (iv) or (v) renders the lease liable to forfeiture. The lease may lie sub-let, in which case the conditions described above are still binding on the lessee as well as on the sub-lessee. Leases may be renewed if the conditions have been carried out to the satisfaction of the British Resident.

The control of all water is in the hands of the State

Licences to use water for mining purposes, if for more than twelve months, are issued by the British Resident under the Mining Enactment. Licences up to twelve months may be issued by the Senior Inspector of Mines, while the Inspector has powers to give orders regarding its distribution in minor cases.

Mining is subject to the following regulations, which may be found in detail in the Mining Enactment of 1928 and Rules hereunder:-

(I) The use and storage of explosives are governed by rules.

(2) Accidents involving death or serious bodily injury must be reported. The circumstances are investigated by the Mines Department, and, if carelessness or blame is attributable to anyone, the matter is taken into court.

(3) A mine manager may draw up •a code of rules for the local government o! the mine, and these, if aoproved, has all the force of law.

(4) Overburden and tailings can be deposited on un worked land only by permission of an Inspector, who may issue directions as to their disposal. Tailings must be retained in dams in such a way that the effluent water does not carry more than 800 grains of solid matter per gallon. In some cases this calls for tailings-retention works of very considerable magnitude, especially on mines using water under pressure.'

(5) Shafting is only allowed under licence. There are various rules providing for the control of mining under ground.

(6) Hydraulic mining of any kind is prohibited except under licence.

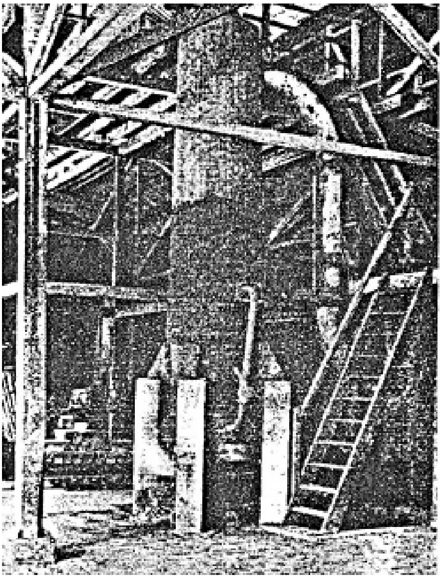
SMELTING.

The smelting of all the tin ore produced by the Federated Malay Sates was formerly done by Chinese in the principal miming districts-Larut, Kinta, and Kuala Lumpur. Small cylindrical blast furnaces were used with charcoal used as fuel.

There is now only one Chinese smelter, in Pudu Road, Kuala Lumpur, where the old type of furnace can still be seen in operation side by side with one small blast furnace of European design. A description is given below. Apart from the ore dealt with here, the whole of the Federated Malay States output is now smelted in the Straits Settlements by two large European companies-the Eastern Smelting Company, Limited, and the Straits Trading Company, Limited.

PRIMITIVE CHINESE TIN-ORE SMELTING FURNACE WITH FORCED DRAUGHT.

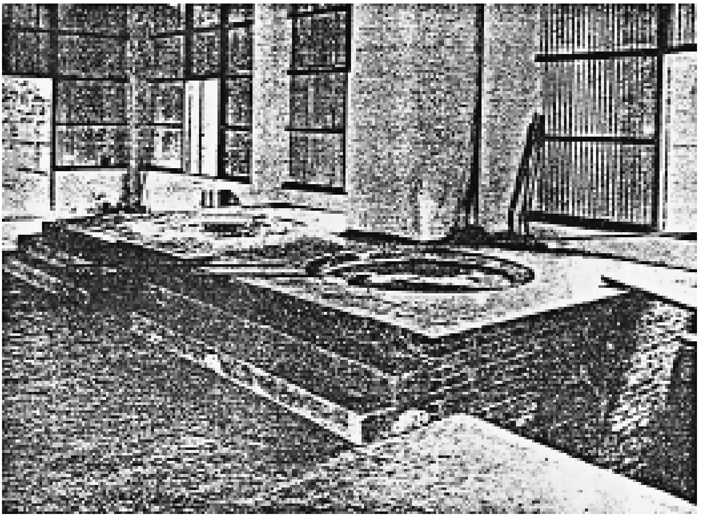
The miner sells his ore as a concentrate of cassiterite, averaging about 75•5 per cent. of metallic tin, either to local ore buyers or to agents of one of the two smelting companies. The buyer weighs each parcel and assays it for its metallic content; the price paid is based on the Singapore price of tin on the day the ore is sold. The smelting companies pay export duty and transport charges, on behalf of the miner, to be taken later from the price he receives. There is also a smelting charge, which consists of a money fee and a deduction from the assay result; these deductions cover the cost of smelting, the loss of metal in smelting, and the smelters' profit. The smelting charge varies with the grade of ore. Ore of low tin content incurs a high smelting charge on account of the greater expense of smelting. In addition, penalties are imposed on ores containing copper, lead, sulphur and arsenic, which have to be eliminated by special treatment.



A MORE ADVANCED TYPE OF CHINESE TIN-ORE SMELTER, SHOWING SCRUBBER ON RIGHT.

The two large smelting companies have modern oil-fired reverberatory furnaces in Penang and Singapore. As a considerable percentage of the tin is volatilized during the smelting process, a fume-recovery plant is essential to save tin that would otherwise escape with the furnace gases. The ore is mixed with limestone and anthracite-the limestone as a flux for the gangue minerals;

the anthracite as a reducing agent for the tin dioxide. Molten tin is tapped from the furnaces at intervals, and, when the charge is completely smelted, the molten slag is run off and a fresh charge is dropped in.

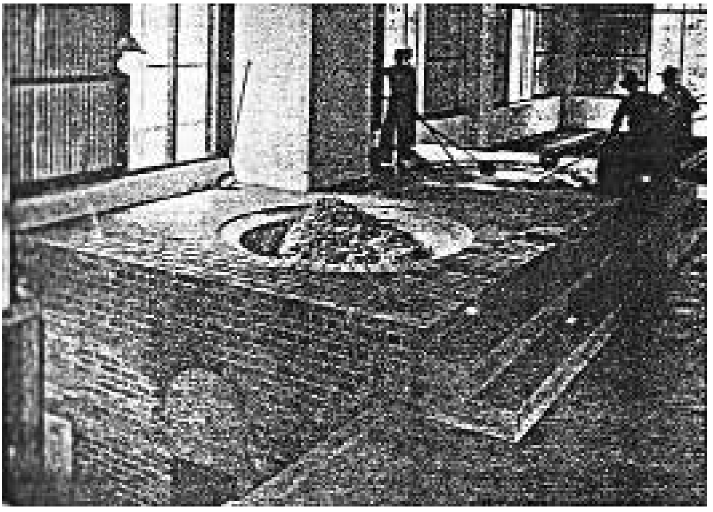


TWO REFINING PANS (CHINESE SMELTER).

The first slag obtained, known as ore slag, contains sufficient tin to be resmelted. From this a final slag is obtained which has a very low tin content, and can be thrown away.

At this stage the molten tin is not sufficiently pure; it is therefore refined in cast-iron kettles by agitation. A dross, containing most of the impurities, is formed on the surface, and is skimmed off at intervals. The refined tin is allowed to settle, and kept at a temperature just above its melting point. After refining, the tin is cast in moulds and sold in 25-ton lots of ingots each weighing 100 lbs. The purity of Straits Tin is between 99•85 per cent. and 99•95 per cent.

Ores which contain arsenic and sulphur require preliminary treatment t before being smelted; they are roasted (calcined) at a temperature too low to cause the ore to fuse and yet sufficiently high to drive off the arsenic and sulphur.



COOLIES AERATING AND SKIMMING SMELT IN REFINING PANS, SKIMMINGS SHOWED IN LEFT PAN (CHINESE SMELTER).

The smelting companies supply bags to, the miner for transport of his ore to Penang and Singapore, and make cash advances as soon as ‘ tin ore is delivered to them, final settlement being made after it has been sold and after its tin content has been determined by assay. A miner can keep in touch with the trend of the London and local markets through the ore-buying agencies of the smelting companies.

Practically the whole of the tin-ore outputs of Burma and Thailand are smelted by the two Straits Settlements companies In addition, they deal also with supplies from South Africa, Australia, Indo-China, Japan and North America.

The following table shows the imports of Tin-in-ore from various countries into the Straits Settlements for 1936, 1937 and 1938:-

Country.	1936.	1937.	1938.
F.M.S.	63,438	73,900	40,326
U.M.S.	1,987	2,034	2,016
S.S.	58	72	113
Thailand	13,043	16,498	14,008
Burma	3,117	3,185	3,288
N.E.I.	42	20	21
Africa	1,250	657	244
Indo-China	1,755	1,809	1,917
Japan	512	695	617
Australia	46	—	—
Alaska	11	—	—
China	157	199	449
Total	85,416	99,069	62,999

The following table shows the shipments of Straits Tin from Penang and Singapore in 1930, 1937 and 1938:-

WEIGHT IN TONS TIN.

Year.	Penang.	Singapore.	Total.
1936	45,835	37,518	83,353
1937	54,838	38,080	92,918
1938	36,238	24,775	61,013

The following table shows the quantities of Straits Tin and destinations to which it was shipped, 1933 to 1938:-

Destinations.	Year 1933. Tons Tin.	Year 1934. Tons Tin.	Year 1935. Tons Tin.	Year 1936. Tons Tin.	Year 1937. Tons Tin.	Year 1938. Tons Tin.
United Kingdom	2,630	4,703	4,065	5,579	7,319	4,215
America	30,864	27,016	41,463	60,069	65,981	35,224
Continent ...	15,383	12,620	10,200	10,692	10,479	9,414
India	2,230	2,449	2,932	2,777	3,044	2,641
China	448	376	844	636	407	209
Vladivostock ...	3	—	—	—	—	—
Rangoon	38	26	42	33	49	32
Indo-China ...	6	15	23	32	80	184
Mauritius... ...	1	—	1	5	1	5
Philippine Islands	19	17	13	94	33	27
Dairen	18	12	5	—	146	398
Bangkok	7	—	8	33	32	25
Honolulu ...	10	25	10	—	15	65
Africa	—	71	49	208	152	277
Australia ...	—	—	—	—	40	64
Dutch East Indies	—	—	—	18	31	17
Japan	2,198	2,760	2,510	3,177	5,109	8,216
TOTAL ...	53,864	50,099	62,165	83,353	92,918	61,013

The importance of the Straits smelting industry is shown by the following figures, which give the total world's production, the Straits' production, and the percentage that the Straits ' production bears to that of the whole world.

Year.	World's Production. Tons Tin.	Straits Production. Tons Tin.	Smelted in Straits. %
1933	91,000	53,864	59·2
1934	115,200	50,099	43·5
1935	147,100	62,165	42·3
1936	180,200	83,353	46·3
1937	208,200	92,918	44·6
1938	148,400	61,013	41·1

The big percentage drop in 1934 is due to supplies of Billiton ore, which were formerly smelted into Straits Tin, being diverted to Holland.

The tin-smelting plant belonging to the Tan Ban Joo Company, Limited, of Pudu, Kuala Lumpur is the only one in operation in the Federated Malay States.

Tin Smelting by Local Chinese

Two blast furnaces of different types are used which are started with a charge of charcoal and logs of mangrove wood in alternate layers. The object of the wood is, not only to effect a quick rise in temperature, but also to ensure that the whole charge of charcoal becomes uniformly heated, otherwise the upper layers of charcoal would remain unburnt. When the whole charge is burning uniformly, about 80 katis (106 lbs.) of tin ore are fed by hand into the top of the furnace, and a similar quantity is added every half hour; further alternate charges of charcoal and wood are given when necessary. About three hours after the first charge of tin ore has been delivered into the furnace, some molten tin is ready to be raked through the taphole, and the process now becomes continuous. Each shift consists of four men working at the furnace for six hours. When sufficient slag has accumulated, it is re-treated two or three times; in fact, as often as an assay shows it to be worth while.

After being raked through the taphole, the molten tin runs into a cast-iron trough, from which it .is ladled into cast-iron moulds arranged alongside. It assays about 99 per cent.
Ingots to the amount of about 230 pikuls (19½ tons) are placed in a cold refining pan, which is then gradually heated by a wood fire. The tin melts, and workmen stir it with long-handled iron ladles to aerate it and to bring impurities to the surface as a scum. This is removed by a long-handled perforated ladle and eventually re-treated in a refining pan.

When sampling has shown that the smelt is pure enough, the refined tin now assaying 99•9 per cent., it is poured into sand moulds, and the ingots are ready to be sold in the Singapore metal market. Negotiations are now in process to sell the refined tin in the London and New York metal markets.

A primitive form of furnace is still in use, but it has been improved by a forced air-draught, and the gases are not allowed to escape until they have been passed through a tank-scrubber. The capacity is 40 pikuls (approximately 2½ tons) of smelt for each 24 hours.

The better type of furnace has a 24-hour capacity of 126 pikuls (approximately 7½ tons) of smelt. It is equipped with an electric rotary blower, and the effluent gases are led through a scrubber and a settling chamber. The refining pans are 7 feet in diameter and 3 feet deep at the centre, with treatment capacity of 400 pikuls (24 tons) in 24 hours. The fuel used is mangrove wood, and the consumption is 2 tons in 24 hours. The weight of a refined ingot is about 90 katis each (120 lbs.).

ADMINISTRATION.

The industry is controlled by the Mines Department, which consists of the following officers, appointed under the Mining Enactment: the Chief lnspector of Mines, a Senior Inspector of Mines for each of the States, Perak, Selangor, and Pahang, and a number of Inspectors. Negri Sembilan is supervised by Selangor officers. All are recruited from approved Schools of Mines. Supervision over the use and safety of machinery is exercised by Inspectors under the Machinery Enactment, and over the ore-buying business by an Inspector under the Mineral Ores Enactment. These Enactments, and the officers appointed to carry out their purposes, are under the administrative cont.rol of the Chief Inspector of Mines.

The Mines Department

The Federated Malay States Mines Department has no responsibility concerning mining in the Unfederated Malay States, nor in the Settlement of Malacca. The only one of the Unfederated States to have its own Warden of Mines is Johore.

The Survey Department

The Federated Malay States Geological Survey Department, administered by the Director, Geological Survey is maintained largely to help the mining industry Survey Department. of the Federated Malay States. Arrangements were made with the Straits Settlements, and with the various Unfederated States, to extend the geological survey into their territories, and, as a result, a geological map of the whole of British Malaya, scale 12 miles to an inch, was published in 1930 and revised in 1938, obtainable at $2•50 each from the Geological Survey Department, Batu Gajah

F.M.S., or from the Malayan Information Agency, London.

A more exact survey of certain districts is now in progress, with a view to estimating their mineral resources. A central record of the results of all the prospecting done in Malaya is being prepared, to assist Government in deciding which land should be reserved for mining. Prospectors are invited to consult this Collection and see what information is available concerning areas in which they are interested; except in the case of State Land-unless the permission of the owner has first been obtained-the value of the ground as indicated by bore-results will not be communicated.

The first application to mine the very deep alluvial ground now being successfully dredged by the Hong Kong Tin Dredging Company, Limited, the Ayer Hitam Tin Dredging Company, Limited, and the KillinghalJ Tin Dredging Company, Limited, was made because of geological information collected and published by the Geological Survey Department, whose work is primarily intended to direct the attention of prospectors to the most favourable localities.

Reports on ore deposits and on the geological structure of mining properties can be furnished at a fee of $50 for each day’s field work, expenses being charged in accordance with General Orders of the Federated Malay States. Assays and mineral analyses are undertaken, and identifications are made of minerals and rocks. This latter service is provided free of charge if .he specimen is from the Federated Malay States, and if the exact locality is disclosed. In cases where the material comes from outside, or where the Federated Malay States locality is kept secret, a small charge is made.

PRESENT LIVING CONDITIONS IN MALAYA.

The climate during the day is hot and damp, and so the lightest clothes should be worn; all of these should be washable, as the least exercise induces profuse perspiration. After sundown, the heat is less, an<l it is comfortable to wear very thin tweeds,

though most people wear washing suits made of cotton or silk.

Twenty years ago it was a rare sight to see anyone wearing shorts, but nearly everyone wears them nowadays, for outdoor work and for games; polo or tennis shirts go well with them. Not so many years back, it was considered the height of madness to go out of doors between 8 a.m. and 5 p.m. without a large sun helmet. Now the solar topee is not seen so often in the towns, where soft felt hats, such as are worn in Europe, are the common head wear, even during the hottest parts of the day; many of the younger generation dispense with all head covering, but opinions are divided as to the wisdom of this innovation. On mines, where the radiation of heat from white sand or rock is so very intense, the topee is still a desirable thing. Many people use dark glasses as a protection against glare.

The length of daylight varies but slightly, the greatest difference throughout the year being about halt-an-hour. Darkness sets in between 6.30 p.m. and 7 p.m. and daylight comes between 5,45 a.m. and 6.15 a,m. Daylight-saving is in force all the year round; Malayan time is 20 minutes in advance of the mean time of the 105th meridian, and 7 hours minutes in advance of Greenwich mean time.

Houses on mines, usually bungalows, are built of wood. A woman may prefer a house with an upper storey, as it gives n. greater feeling of security. The walls are usually of wood and the roof of "attap". A typical house consists of a living-room, a dining-room, and two or more bedrooms, each with a bathroom attached. Verandahs are essential to keep out both glare and heat.

The bathroom is, of course, a most important place. Long baths with hot and cold water are becoming more common in the towns, but elsewhere in the mining districts there still prevails the much more primitive mode of bathing that was almost universal until ten years ago, and, indeed. is very suitable for this damp, hot climate. It appeals as novel to anyone straight from home. The bather stands outside a large wooden tub, or Shanghai jar filled with cold water, and pours deliciously cool streams over him with a small tin pail It is an extremely refreshing form of bath.

The quality of the food supply varies considerably with the distance from the main towns. When transport is available, excellent meat, butter and other foodstuffs can be obtained from the Cold Storage Company, which have depots in practically all towns. Most .of their supplies come from Australia and New Zealand. Potatoes are obtained from India, but other vegetables are grown locally, and, unfortunately, they are rather tasteless. Of recent years a new hill station has been opened up at Cameron Highlands, and a limited quantity of potatoes and fresh vegetables is available from there; in time there will be a much larger supply. Salad-vegetables, such as lettuce, should not be eaten if they have been grown by Chinese gardeners, owing to the danger of typhoid. Chickens, ducks and eggs are easily obtainable and local pork, beef, and buffalo meat can be eaten, but they are not so good as meat from the Cold Storage. With the present transport facilities, however. there are but few places where Europeans must rely entirely on local foods.

The cost of living, of course, varies greatly with the locality of the mine, and with the resources and tastes of the individual, but the following figures, obtained from every part of the Federated Malay States, will give an idea of what it costs a mine assistant to live, if he is a man of inexpensive habits. In the towns there is much more scope for spending money.

It may be taken that the management will supply a house and furniture free, though it may be necessary, for additional comfort, to augment the furniture. Firewood, lighting (usually electric) and medical attendance-sometimes for the employee only-are also provided. The company usually pays for a coolie as a water-carrier and handyman. and sometimes for a gardener also.

Figures have been received showing that a. single man can live quietly on a mine at an inclusive cost of about $200 a month, equivalent to about £280 a year. This includes food and liquor, clothes and amusements. The cost of living is largely reduced by joining a mess. A married mine assistant, without any children, would need about $300 a month, £420 a year.

These figures represent the minimum, and do not allow for anything except living in a very quiet way, nor do they allow for the medical expenses of the man's family.

With the exception of malaria, the country is extraordinarily free from disease. This happy condition of affairs may be attributed to the natural healthiness of the climate, strongly reinforced by strict quarantine at the ports of entry, and by very prompt action on the part of the medical authorities in the event of an outbreak. A few cases of smallpox are heard of. Malaria unfortunately is common, and there are several conditions which may make it prevalent. It is imparted by the bite of a mosquito known as anopheles, several varieties of which are known in Malaya They are not dangerous until they have fed on the blood of an infected subject, after which they may transmit parasites to their next victim. The subject is exceedingly complicated, and although much is known, there are still many points that require research.

Many preventive measures are practised. The breeding places of dangerous mosquitoes are usually in small running streams and springs. Such can be enclosed in clean drains and oiled regularly so as to kill the mosquito larvae. There are many other mosquitoes besides the dangerous anopheles, all of which breed in water, so that care should be taken that no stagnant pool, however small, is left in the vicinity of the house. Even though all these pests do not cause malaria, yet they are a source of constant annoyance if allowed to flourish without hindrance; any receptacle, such as an empty tin, or anything capable of retaining water, may provide a breeding place. Mosquitoes lurk in dark places, and cupboards should therefore be swept out at intervals.

The mosquito-net which covers the bed at night is a most important preventive, It should be made without any entrance door, but opinions are divided as to whether it should be tucked in under the mattress, or made a foot or more larger than the bed, long enough for the end to lie on the floor and be held down by weights sewn into the hem. The first method keeps mosquitoes out, but does not prevent infection from bites on those parts of the body which may be touching the net. If the net reaches the floor, it is essential, before closing it, to disturb and drive out any mosquitoes that may be hiding under the bed.

RESTRICTION.

In the year 1927, the production of tin, stimulated by the high price which had ruled for two years, began to run in excess of consumption, and a continuation of this state of affairs, and consequent accumulation of stocks, caused the price had fallen to about £180 a ton.

Consumption, which had steadily increased up to the end of 1929, began to decrease in 1930, and, by June of that year, stocks of tin had reached 46,000 tons. The market was unable to cope with this enormous volume; the price fell to £135 a ton, and the position threatened to get mucb worse.

These were the decisive factors which led to the introduction of the Control Scheme, by which the intention was to secure a fair and reasonable relation between production and consumption, with a view to prevent rapid and severe oscillations of price, and ensure the absorption of surplus stock. A three years agreement was signeJ on 1st March, 1931, by the following countries: Bolivia, Malaya, the Netherlands East Indies and Nigeria; Thailand also agreed to participate. The standard tonnages of the Signatory Countries at the end of 1938 were as follows:-

Belgian Congo	13,035	tons tin (metal).
Bolivia	46,027	,, ,,
French Indo-China	3,000	,, ,,
Malaya	77,335	,, ,,
The Netherlands East Indies...	39,055	,, ,,
Nigeria	10,890	,, ,,
Thailand	18,628	,, ,,

These figures represent the amount which each country will be allowed to produce if and when the at 100 per cent quota is fixed at 100%.

The year 1938 was one of low quota releases and difficult times for tin miners in general, the quota averaging 55-64 per cent International and 41•2 per cent Domestic against 107-5 per cent International and 77•75 per cent Domestic during 1937. As a. result of this drastic cut there were 263 gravel-pump mines, 40 dredges and 30,000 coolies less, operating at the end of the year than at the beginning, and Government has spent over half a million dollars in unemployment relief works.

The administration of Tin Restriction in Malaya is under the control of the Mines Department assisted by a Committee. The work is carried out in addition to the normal duties of administration of the mining industry.

The 1938 Domestic annual assessment of the Federated Malay States is, at present, about 98,230 tons, which means that, with a Domestic quota of 100 per cent., the mines now actually in existence would produce 98,230 tons of tin. The Unfederated Malay States and Malacca are allotted about 3,200 tons of standard tonnage to be deducted from Malaya's standard production of 77,335 tons.

The following table shows the different percentages of restriction since the inception of the scheme;-

TABLE OF QUOTA PERCENTAGES.

	International Percentage.	F.M.S. Domestic Percentage.	
1931—			
March-May ...	77·7	75	
June-August ...	65·4	75	
Sept.-December...	65·4	40	
1932—			
January-May ...	56·2	40	Byrne Scheme in operation.
June	43·8	33⅓	
July-December ...	33⅓	25	

TABLE OF QUOTA PERCENTAGES (continued).

	International Percentage.	F.M.S. Domestic Percentage.	
1933—			
January-March ...	33⅓	25	Byrne scheme in operation.
April-June ...	33⅓	23	
July-December ...	33⅓	25	
1934—			
January-March ...	40 + 4	31	Special 4 per cent. allowance for one year from which F.M.S. over-production prior to 31/12/33 of 1,031 tons has to be deducted.
April-September	50 + 4	37·5	
October-December	40 + 4	30	
1935—			
January-March ...	40	28·3	
April-June ...	45	32·4	
July-September	70	46·7	
October-December	80	62	
1936—			
January-March ...	90	65	
April-June ...	85	62	
July-September...	90	65	
October-December	105	76	
1937—			
January-March ...	100	72	
April-June ...	110	79	
July-September...	110	80	
October-December	110	80	
1938—			
January-March ...	70	56	As a result of concessions by Bolivia, the Belgian Congo and French Indo-China, approximately 11,500 tons tin were distributed between Malaya, the N.E.I. and Nigeria in proportion to their Standard Tonnages. This distribution resulted in Malaya being permitted to export at the rate of 80 per cent. quota release during the first quarter, 1938, and at the rate of 62·56 per cent. during the second quarter.
April-June ...	55 + 7·56	43	
July-September...	35	25·5	
,, (Buffer Stock)	10	7·6	
October-December	35	25	
,, (Buffer Stock)	10	7·8	

It is readily seen to what an extent tin mining in the Federated Malay States has been curtailed as a result of control. Actually, restriction is more severe than is shown by these figures, for the domestic assessment of 98,230 tons does not represent the potential production; this, really, is nearer 100 ,000 tons.

GENERAL.

The foregoing will convey an impression of the nature of the mineral deposits in the country, the methods adopted for winning them from the ground, and the conditions under which such \\'ork is carried out. The last twenty-five years have seen many changes in tin mining. The exhaustion of the. majority of the known rich deposits has called for much more stringent conditions of economy.

Gravel-pump mining by Chinese is accountable for a big percentage of Malaya's tin output, but the areas concerned are much smaller than dredging areas; in 1938, dredging produced 412,524 pikuls of ore, and gravel-pump mining 350.955 pikuls. More attention is being paid to the use of electricity on dredges and in gravel. pump mines, and the present tendency is to work on a larger scale with big areas. Dredges are made larger and larger, with a corresponding increase in digging and treating capacity and a consequent reduction in costs. Although the bucket dredge is popular because of its low cost per cubic yard, yet it is not an ideal form of mining in all areas. Where the bottom is soft, as with shale or decomposed granite, the ore-bearing ground can be cleaned up very thoroughly; but where t he bottom is eroded limestone, as it is in so many places. it is impossible for the buckets to clean up all the ore, and such as remains between the pinnacles may be lost for ever. In this respect the suction cutter dredge is more satisfactory in that the ground lying between the limestone pinnacles can be got at and removed. Taking it all round, however. the suction-cutter type has not proved a success in this country and is not likely to solve the problem of removing economically the tin-bearing ground lying amongst limestone pinnacles. It is probable that big areas in Malaya, dredged by inefficient and out-of-date machines, will pay to re-dredge in the future.

Eventually there will be no payable flat areas left for dredging, and attention will then be directed to the problem of extracting tin ore from the hills, the value of which it is quite impossible to estimate. If ever the Government decide to permit largo scale hill mining, it will be necessary to set aside enormous areas on the flat for the retention of tailings. It has been proved, by experience, that tailings cannot be impounded effectively by the construction of dams across valleys through which flow perennial streams, but that they can be permanently retained on the flat by isolating them from all flood water other than that of the area in which they are impounded. The most economical way of working the hills will be by hydraulicing, which will, in due course, expose the outcrop. of lodes. Ultimately, no doubt, lode mining will outlive every other form of mining for tin.

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Acting Chief Inspector of Mines,
Federated Malay Sales

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14th October, 1939.

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