

An Investigation of the Composition and Treatment of the Tin-bearing Gossan and Sulphide Ores of Renison Bell, Tasmania.

INTRODUCTORY.

In this investigation all assay returns are given as metallic tin, with the exception of the analyses, where the tin is stated as the mineral tin-oxide.

No tin, either in the gossans or sulphides, was soluble in acids. The tin was found to occur as oxide only.

In assaying chemical methods were used exclusively with preliminary acid cleaning. In low-grade material a weight of 2 or 3 grams was taken for each determination.

In the sizing tests the screens are described by the number of meshes per linear inch. The wire of the screen being the same width as the aperture, it follows that the width of the aperture is one-half that indicated by the number of meshes. Thus, a one-hundred mesh screen has apertures one two-hundredth part of an inch in width.

The silica sited in the analyses is the portion of the ore which is insoluble in acids, minus the tin oxide. While not quite correct, it is near enough for the purposes of comparison.

GOSSAN ORES.

These ores are the product of the oxidation *in situ* of the pyritic ore-bodies, and constitute the source from which by far the greater proportion of the tin obtained on Renison Bell has been won. The gossans are found overlying the sulphides. These oxidised ores have always been a subject of interest and speculation to the assayer on account of the wide difference in the tin content as given by the vanning assay and that shown by the chemical assay.

Working on ores of from 1 to 2 per cent. tin, after crushing through a 60-mesh screen and making a concentrate of between 60 and 70 per cent. tin, the vanning

2/9

assay would give a return of from one-third to one-half of that obtainable by the chemical methods. A new mineral, an oxidised combination of tin and iron, was postulated. The difficulty of accepting this view was that the gossans are the product of the weathering of the sulphides, hence the new mineral would primarily have to exist as such in the sulphides. It has, however, been recognised in the investigation that the divergence in the assays is caused solely by the physical condition of the tin-oxide. This mineral is generally distributed through the ores in a very fine state of division.

An average analysis of the gossans, taken from three faces, would be:—

	Per cent.
Tin oxide	2.04
Hydrated iron oxide	45.16
Silica	52.8
	<hr/>
	100.00

EXPERIMENT 1.

A sample of ordinary run of mine ore was taken over a period of some weeks—tin content, 1.55 per cent.

A stock sample was crushed through a 30-mesh screen. A part was taken, and gave a concentrate of 66 per cent. tin and a recovery of 32.8 of the total tin.

Sizing tests were conducted on 40, 60, 80 and 100 mesh screens. As the tin oxide is evenly distributed, the values of the stock sample and the oversizes did not exhibit any great difference. No saleable concentrate could be made from any of the oversizes. Forty-nine per cent. of the sample passed through a 100-mesh screen.

This material gave a concentrate of 65 per cent. tin and a recovery of 59.2 per cent. of the amount of tin present.

A portion of the stock sample was crushed through a 100-mesh screen. This gave a concentrate of 60.8 per cent. tin and a recovery of 59.6 per cent. On regrinding the tailing a further recovery of 9 per cent. was made. Total tin extraction, 68.6 per cent.

The tailing is a hard siliceous material (the iron oxide having been mostly slimed and washed out), from which the tin oxide separated readily when released by the fine crushing. The loss by sliming is less than anticipated, the tin being more closely associated with the siliceous gangue than with the iron oxide.

Crushed direct through a 200-mesh screen, a concentrate of 68.3 per cent. tin was obtained, and a recovery of 53 per cent. made. The high-grade concentrate was easily separable from the gangue, but the recovery was not so good as when the ore was crushed through the 100-mesh screen. With very fine grinding the loss in sliming becomes an economic factor.

EXPERIMENT 2.

Gossan ore—tin content, 1.55 per cent. This ore was first roasted, with a loss in weight of 8.5 per cent. After crushing through an 80-mesh screen a concentrate assaying 60 per cent. was made, with a recovery of 33.2 per cent.

Roasting is detrimental to the extraction, and gossan ores should not be intentionally mixed with sulphide ores in roasting.

EXPERIMENT 3.

Gossan with fine tin oxide—tin content, 1.34 per cent. The stock sample crushed through a 30-mesh screen gave a concentrate of 56 per cent. and a recovery of 30 per cent. In the sizing tests no saleable product could be made from the oversizes.

A quantity equal to 45.8 per cent. of the sample passed through the 100-mesh screen. This gave a concentrate of 62.2 per cent., and a recovery of 48.1 per cent.

Crushing direct through a 100-mesh screen, a concentrate of 61.2 per cent. was obtained, with a recovery of 61.8 per cent. Regrinding of the tailing gave a concentrate of 60.6 per cent., and a further recovery of 7.1 per cent. Total recovery, 68.9 per cent.

Crushed direct through a 200-mesh screen, a concentrate was made which assayed 62.1 per cent. tin, with a recovery of 59.6 per cent. of the total tin.

EXPERIMENT 4.

Gossan, with the tin oxide in an exceedingly fine state—tin content, 1.73 per cent.

The stock sample crushed through a 30-mesh screen gave a concentrate of 59.4 per cent. tin, and a recovery of 14.3 per cent.

In the sizing up to 100-mesh no product could be made from the oversizes.

4/9

The even distribution of the fine tin is well illustrated by the sizing products:—

Stock sample—

Retained on 30-mesh, nil; per cent. tin, 1.73.

Oversize—

Retained on 40-mesh, 19.5 per cent.; per cent. tin, 1.77.

Retained on 60-mesh, 13.4 per cent.; per cent. tin, 1.50.

Retained on 80-mesh, 15.4 per cent.; per cent. tin, 1.77.

Retained on 100-mesh, 10.1 per cent.; per cent. tin, 1.75 per cent.

Through 100-mesh, 41.6 per cent.; per cent. tin, 1.75.

Of the stock sample, 41.6 per cent. went through the 100-mesh. This gave a concentrate of 63.4 per cent., and a recovery of 25.6 per cent.

Crushed direct through the 100-mesh, a concentrate of 60.9 per cent. was made, and a recovery of 34.8 per cent. The tailing reground gave a concentrate of 54.6 per cent., and a further recovery of 10.1 per cent. Total recovery, 44.9 per cent.

Crushed direct through the 200-mesh screen, this gave a concentrate of 60.0 per cent., and a recovery of 48.5 per cent.

It is problematical if a saving of more than 50 per cent. can be effected on this ore. Although the finer the grinding the more tin oxide is freed, after a certain point is reached the sliming loss offsets this advantage.

By the above and other sets of experiments it has been demonstrated that, on the whole, the fairly good extraction of about 65 per cent. of the tin may be obtained from those gossans. A specially-designed mill will be required, with more than the ordinary regrinding and slime-saving appliances, and with ample settling accommodation.

SULPHIDE ORES.

In the Renison Bell district the sulphide ores, without exception, replace the gossans at a comparatively shallow depth. The various sulphide masses vary considerably in composition and tin value. Every sample treated was tested for tin sulphide, but none was found. This accords with the fact that stannite, a rather conspicuous mineral, has never been observed with the pyrites.

5/9

EXPERIMENT 5.

Bulk sample of ore taken across a working face for a width of 20 feet:—

Analysis.

	Per cent.
Tin oxide	1.55
Silica.....	15.80
Arsenical pyrite	1.50
Iron pyrite with a little magnetic pyrite	81.15
	100.00

After crushing through an 80-mesh screen, an effort was made, without roasting, to concentrate the tin oxide into a small quantity of pyrite. The best product that could be obtained without very heavy loss assayed 28.6 per cent. tin, and gave a recovery of 34.4 per cent. of the tin in the sample.

After crushing and roasting, the ore was reground through an 80-mesh screen. A concentrate was obtained which assayed 59 per cent., and gave a recovery of 60 per cent. A regrinding of the tailing produced a concentrate of 57.2 per cent., and a recovery of 8.8 per cent. Total recovery, 68.8 per cent.

EXPERIMENT 6.

A bulk sample of iron pyrite taken across a width of 6 feet:—

Analysis.

	Per cent.
Tin oxide	0.77
Silica.....	9.00
Iron pyrite	90.23
	100.00

Before roasting, and after crushing through an 80-mesh screen, the best concentrate obtainable without heavy loss assayed 15.75 per cent., and represented a recovery of 32 per cent.

6/9

After roasting and crushing through an 80-mesh screen, a concentrate was made assaying 65 per cent. tin, which gave a recovery of 71.6 per cent. tin, without regrinding the tailing.

When tin occurs in the iron pyrite with a small quantity of silica, a high-grade concentrate and a good extraction are assured.

EXPERIMENT 7.

Bulk sample of a working face taken over a width of 12 feet:—

Analysis.

	Per cent.
Tin oxide	1.86
Silica	49.50
Arsenical pyrite	2.80
Magnetic pyrite with a little iron pyrite... ..	45.84
	<hr/>
	100.00
	<hr/>

Before roasting, and after crushing through an 80-mesh screen, the best concentrate obtainable, without undue loss, assayed 19.05 per cent. tin.

After roasting and regrinding through the 80-mesh, a concentrate was obtained of 54.2 per cent. tin, and an extraction of 57.9 per cent. Regrinding the siliceous tailing, a concentrate assaying 55 per cent. was made, with a further recovery of 12.5 per cent. Total recovery, 70.4 per cent. of the tin in the ore.

By crushing, roasting, and regrinding before concentrating, a higher recovery can be obtained from the sulphide ores than the recovery made in the treatment of the oxidised ores.

Several experiments were made on the lines of making a low-grade sulphide concentrate, preparatory to roasting; But with a concentrate containing only 3 to 5 per cent. tin the losses were too heavy. There is little prospect of commercial success in the procedure of concentrating before roasting. Unfortunately, this was the method adopted on the Renison Bell field, the companies, no doubt, being influenced by the heavy expenditure involved in the installation of a roasting plant capable of handling a large quantity of ore.

It must be understood that the foregoing remarks apply to the heavy sulphide ores. With a decreasing percentage of pyrites, a stage is reached when it is better practice to concentrate before roasting. This may be easily determined by analysis of the ore, in conjunction with concentration experiments and a consideration of the recoveries and relative costs.

FLOTATION METHODS.

A series of tests were carried out on the pyritic ores by flotation. It was established that it is possible to make a separation of a fairly clean siliceous residue and a fairly clean pyritic product. The obtained residues, assaying from 2.5 to 3.5 per cent. tin, contained from 38 to 64 per cent. of the tin in the stock samples. The recovery was influenced in the same ratio as the amount of silica in the ore. As the laboratory was not provided with testing machines, it was found necessary to first remove the slime. On an average this slime weighed one-quarter of the crushed sample, and assayed one-half per cent. tin. Owing to the fineness of the tin oxide, there was a tendency for it to be carried over with the pyrites.

The flotation processes do not seem so adaptable to these sulphide ores as the simple preliminary roast, followed by regrinding and concentration. But before a final decision is given, it will be necessary to have bulk samples treated by specialists in a laboratory equipped with the different flotation machines.

ECONOMICS.

Gossan Ores.—Of the tin, to the value of a quarter of a million pounds sterling, which has been despatched from Renison Bell, the gossan ores have contributed the greater quantity. The deposits now show signs of exhaustion, though at the present rate of consumption there is sufficient to last for some years, and it may be found practicable to draw on the untouched reserves of the X River district.

The difficulty of obtaining a fairly good extraction of the tin in the ores is not insuperable. It may be attained by the erection of one specially designed mill or the remodelling of the old mills.

Sulphide Ores.—On the successful treatment of these ores depends the real prosperity of the field. The different lodes and masses range over a wide area, and their aggre-

gate tonnage must be very great. It is outside the scope of this investigation to estimate the quantities and values. This knowledge can only be acquired by surveys and extensive sampling and assaying, and the cost will be considerable. Suffice to say that the proved existence of large masses of pyrites, which bulk over 1 per cent. tin, present an attractive commercial proposition. The ore can be cheaply mined, and crushes easily. By roasting and regrinding before concentration, a recovery of 70 per cent. may be secured—a better extraction than can be got from the gossan ores.

But, it must be added, while some of the sulphide masses give satisfactory assay returns, others of equally promising appearance bulk very poorly. A thoroughly wide examination is needed before a correct conception of values is possible.

Whatever action is taken to exploit the ores should be preceded by an amalgamation of the various mining interests of Renison Bell. This will ensure the erection of a complete central works, capable of handling large quantities at a minimum cost. The undertaking should not be approached in a small way by separate companies.

GEOLOGY.

No reference need be made to the geological features of the district, as this subject has been fully dealt with and brought right up to date by Mr. Hartwell Conder, A.R.S.M., in Geological Bulletin No. 26.

THE ASSAY OF TIN.

As the correct assaying of tin ores may have a most material effect on the prosperity of a district, a short review of the processes is considered to be warranted.

The Chemical Methods of Assay.—During the last few years great advances have been made in the art of determining the true content of the tin in ores and other combinations. By use of the chemical methods that have been evolved, the assayer can easily and accurately estimate the tin, no matter how complex the ore or how fine the distribution of the metal. The establishment of a positive method of assay must invariably precede metallurgical improvements. The losses in treatment have to be fully realised before the necessity for change in the metallurgical practice is grasped.

In the case of tin—a high-priced commodity—it appears strange that in this connection it has lingered behind lead, copper, and other industrial metals. There are, however, indications that a change is imminent, and that future work will be conducted on a more scientific basis.

The Vanning Assay and Reporting as Tin Oxide.—The vanning assay on Renison Bell ores fails to give even approximate results. On from 1 to 2 per cent. ores the vanning return is from one-third to one-half the true tin content. On clean ores with coarse tin oxide and a light siliceous gangue, the method may be operated to give indications quickly, but at the best it is very uncertain, and should never be used for important work.

The custom of stating returns as tin oxide should be discontinued. If the tin oxide were taken as pure, with a percentage of 78.7 of tin, the practice would still have nothing to recommend it. It is more simple and direct to give the percentage of metallic tin. As used at present, the term "tin oxide" is vague and unsatisfactory; it may mean a substance that may vary in tin content within wide limits.

The Fire Assay of Tin.—In experienced hands this assay on pure ores will give a return very near the true value; but on lode tin, with the usual associated interfering elements, the result is not so reliable. On low-grade ores a preliminary concentration must precede the reduction, with the unavoidable loss. Acid-cleaning before fusion, or refining the button after reduction, is required. The employment of an unpleasant and dangerous reagent is necessitated. Altogether the method may be abandoned with advantage in favour of the chemical methods.

In this regard, Mr. L. Parry, the author of the "Text-book on the Assaying of Tin and Antimony," says of the fire determination of tin, "It is worse than bad assaying; it is dishonest."

Presumably, Mr. Parry is not acquainted with the vanning assay, and the reporting of the metal as tin oxide, or he would not have written so forcibly of the fire assay

J. H. LEVINGS, A.Z.S.M.,
Government Mining Engineer.

Zeehan, Tasmania, 14th October, 1920.