8th August, 1889.

ON A SIMPLE METHOD OF EXTRACTING GOLD AND SILVER FROM PYRITES BY A NEW WET PROCESS.

By Dr. John Storer.

The successful extraction of gold and silver from pyritic minerals is, in the author's opinion, the most important problem before the mining industry in Australia. The days of easily won gold are gone. Surface ores, which are in general easily treated, are largely worked out, and, as has been well said, "We are coming to the period when we shall have to attack the real wealth of the country which is contained in the poor and the so-called "rebellious ores" of which there are, and always have been, plenty. The use of the word "rebellious" has been the cause of the loss of much money. It is one of those words behind which men are willing to attempt to conceal great ignorance. If, instead of using this word, it had been said that rebellious ores are those which we do not know how to treat, men would not have ascribed an active principle to the ore as though it were resisting them; but might have constantly worked at the problem of treating it until some successful method had been found.

Under existing conditions much of the gold, even of what is known as free gold, is not saved. It will not amalgamate, is rusty perhaps—is either naturally "float" gold or gets beaten in the mills into a condition equivalent to float gold.

If the gold be associated with much silver it is more difficult of amalgamation, and a correspondingly increased liability of loss takes place. Then, again, the pyrites is now found to be a great store house of gold—and of gold in a state which absolutely resists direct amalgamation. In past years, the bulk of the pyrites was run to waste in the tailings coming from the mill; but now adequate concentrating appliances are at the disposal of all, and, by their

means, an almost perfect separation of the pyrites from its associated gangue can be made.

It may not be out of place at this point to observe that in Mexico, where the slow grinding arastra is used, higher yields of gold per ton are got by it than with the best modern machinery. The slower but more perfect process of the arastra has brought the pyrites into such a fine state of division, and by constant abrasion of the stone rubbed it so bright that the mercury took the gold up. The principle of the machine (the arastra) is a good one, and a well-known American metallurgist has given it as his opinion that to that principle we must return. It is a matter of great surprise that a machine has not yet been invented to work rapidly on the principle of the arastra. No machine yet invented can compete with it in the efficiency of its work. There is here a large enough industrial field for the inventive powers of engineers.

The crushing of the gold containing mineral is not the greatest difficulty. The trouble begins in endeavouring thoroughly and economically to save all the contained gold. The losses are many. Float gold the author has already alluded to. Then again, the stamps in the battery seem in many instances to cover the grains of gold with a silicious coat due to impalpable quartz powder, which is hammered into the yielding metal. This skin prevents proper contact between the gold and the mercury, hence such grains escape amalgamation. Gold which has been simply hammered, for some yet unknown reason, shows a greatly diminished affinity for mercury. It is on record that gold pounded on a clean smooth anvil with a hammer has been left in contact for a week with mercury without amalgamation. Absolute contact is necessary for amalgamation, and the thinnest film between the gold and the mercury will prevent it. One of these coatings or films is oxide of iron—grease from the stamp, or which may be in the water used, will produce negative results—a very small amount of sulphuretted hydrogen will produce exactly the same effect, leaving an impalpable greasy film on the outside which prevents the action of the mercury. Clay, talcose mineral, or steatitic matter are also more or less prejudicial. In drawing attention at some length to the troubles

experienced in saving free gold, the author has done so in the hope that it may be the means of directing more attention to the intelligent working of the crushing and amalgamating mills, now in operation in the colonies; and he would ask you to look upon these remarks as introductory to the special object of this paper.

The pyritic minerals now saved by means of concentration, and consisting of sulphur compounds of the base metals (iron, copper, lead, zinc, antimony), contain, or carry with them much of the gold, and from them in the future we must look for the bulk of our gold supply. Its extraction, then, is no longer a mere mechanical process, but involves roasting, and other intricate and delicate processes known to metallurgists. Many a mine depends really for its success upon the adoption of the most suitable method for dealing with the sulphides, and that method is not always discovered in time to save the company from liquidation. A rich ore is by no means synonymous with large profits.

Many processes known for working sulphurets have been invented, tried, and have also died. Plattner's process, now known as the "Chlorination" process, is almost the only one that still lives. It, as is well known, consists of roasting the sulphurets to expel all the sulphur, and then extracting the gold by chlorine. It has been adopted and improved in its detail and, whilst it was for long thought to have solved the question, it is now a matter of every day knowledge that in many cases it is not a suitable method of extracting the gold. There are substances in the gangue, for instance, lime and magnesia, and other substances associated with the gold, such as lead, copper, and zinc, which would be attacked by the chlorine, and thus use up that re-agent without producing any effect. Again, there are conditions in which the gold after being dissolved out might be again precipitated, and thus be still left in the tailings. In brief, the chlorination process, to be worked successfully, is only applicable to ores in which there is nothing but the gold to be attacked by the chlorine, and nothing which would prevent its acting on the gold.

Should the ore contain any silver this would be attacked by the chlorine, and a coating of insoluble chloride of silver get

formed over the gold: this will prevent further attack by the chlorine, and not only will the silver be entirely lost, but any particles of gold contained in it will also be lost.

To sum up the position as regards sulphuret ores carrying gold, chlorination is as yet the only working method of extracting the gold, leaving out smelting of course, but there are many ores which cannot be profitably handled by it, whilst in every case where chlorine is used all the silver is lost. Chlorination is also a process which requires for its successful working no inconsiderable amount of chemical knowledge and skill. Direct amalgamation, we have seen, is of no avail, for we require actual contact between the mercury and the gold, and that has not hitherto been attained with pyrites. Could we succeed in putting the gold and silver in the pyrites in a state fitted for amalgamation with mercury, we should have a process at our disposal.

And this is the basis of the new method of gold extraction, which the author has the pleasure of bringing before you. The idea is the invention of Mr. L. O'Brien, of Sydney, and is the outcome of a method which he has been successful in applying to the extraction of cobalt from the manganiferous cobalt ores, of which large deposits exist in New South Wales. He employs sulphurous acid, obtained directly from the combustion of sulphur or pyrites. This gas when injected under pressure into a vat containing the finely ground mineral mixed with water, dissolves out the contained cobalt, some of the iron existing as iron oxide, etc., leaving the cobalt in solution in a convenient form for being treated further. We have seen that the gold in pyrites will not amalgamate with mercury owing to the intervention of some base material, often oxide of iron. Trials were, therefore, made with roasted pyrites to see if the sulphurous acid would not clean the gold particles by dissolving off or removing impurities, and leave the gold in a clean state for amalgamation with mercury. Good results were obtained.

One important benefit is obtained by this new method, viz., that whilst with the chlorination process only the gold can be saved, by this method much of the silver is also recovered.

Epitomised the method consists :—

1st. Of roasting the gold-bearing pyrites or pyritic concentrates.

2nd. Subjecting the roasted mineral to a treatment with sulphurous acid for a time, varying according to the nature of the ore from 24 to 30 hours.

3rd. The resulting residue being washed with water is amalgamated with mercury in the usual way and the gold recovered. Large quantities of pyrites can be treated at one time, and an experimental plant capable of handling about two tons at one operation is now in course of completion.

And now as regards the results obtained from pyrites. Working upon pyrites got from Ravenswood, Queensland, and this was selected as being of a well known refractory nature,

The gold extracted was—	91·94 per cent.,	88·62 per cent.,	94·8 per cent.
Silver	72·84 „	60·49 „	71·6 „

Or an average yield of :—

Gold	91·78 per cent.
Silver	68·31 „

In these results there is one point to which attention may be drawn, and that is the percentage of silver extracted. It averages 68·31 per cent, yet this is all gain compared with the chlorination method, where no silver at all is got; with many ores loss in silver is more than equal to what the cost of working would be. Why less silver than gold is recovered, is a question to which the author cannot yet give an answer; indeed, what the exact line of chemical action involved in the whole process is, will take time to thoroughly work out; but he hoped to bring that matter before you later on, this paper being more to acquaint you with the fact of what results have been obtained, and the means by which they have been arrived at.

It will be seen that in this process we would appear to have a method at once simple and cheap, by which we can win the gold. The pyrites itself will yield, during roasting, sulphur to supply the needful sulphurous acid, thus making the process independent of outside chemicals. Even at the best and under the most favourable

conditions, the cost of carriage on the chemicals, without taking note of the cost of the chemicals themselves, required in chlorination, is great, and in many cases, especially in Queensland, the difficulties of transport render the adoption of that process an impossibility. All this is avoided by the method described. There is no complicated apparatus required; the sulphurous acid being injected directly into the water vats from the burners by means of a simple steam injector, thus using as the active substance to free the gold, that sulphur which hitherto has gone to waste. The element of cost is the crucial point upon which the existence of any industrial method rests, and here it will be evident to you all that little fault can be found. Gauging the costs of this method by the working results obtained in working the cobalt extraction, previously alluded to, the costs will be considerably under 20s. per ton of pyrites treated; doubtless this will be modified as experience is gained.