

REPORTS

ON THE PRESENT CONDITION

OF THE

Canada Consolidated Gold Mining Company's

PROPERTY

AND ON THE

TREATMENT OF ITS ORES

AT

DELORO, ONTARIO.



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1883.

REPORT OF
RICHARD P. ROTHWELL,
SUPERINTENDENT.

To the Trustees of the Canada Consolidated Gold Mining Company :

The present condition of the company's property is as follows: No work has been done by the company on any of the numerous small veins. The main vein, which has not been worked since July, 1882, is opened to a depth of 170 feet, and the pay chute over a length of about 750 feet by shafts and levels aggregating about 1100 feet in length. The ore in the vein certainly exceeds an average thickness of eight feet, and probably will run very much more than this. The quantity of ore in sight is sufficient to supply the present works for several years.

The mines are in a position to produce 100 tons a day. The double engines and boilers for permanent hoisting-works—to hoist from two shafts from a central point—are on the ground (the boilers being included in the chattels sold), and the friction-drams are being made in Pennsylvania.

The tram-road, with its iron cars for taking the ore from the mines to the mill, is in good order.

The concentrating mill has a proved capacity of fully 100 tons in 20 hours, crushed to a maximum size of $1\frac{1}{2}$ mm. As much as 7 tons an hour have been put through.

The roasting is done in a continuous operation without handling, in two revolving cylinders, which have a proved

capacity of 10 tons concentrates per 24 hours. This is equal to from 40 to 50 tons of ore (varying with proportion of sulphurets in ore), or about one half the mill capacity.

The chlorinating and filtering capacity is about 10 tons per day, or the same as furnace capacity.

To increase the roasting and chlorinating capacity to 20 tons per day, or to the possible mill output, would cost from \$15,000 to \$18,000.

The entire cost of treating 50 tons of ore per day is given as follows. In this I have counted wages at \$1.50 per day, which cost us from \$1.25 to \$1.40; and wood at \$2.50 per cord, while we believe it can be purchased in winter and delivered for \$2. I have also added one man per shift to the mill, and one to each shift in the roasting and chlorinating, more than are necessary for the work. Also, the quantity of wood is based on the consumption of green wood, mostly basswood, which has recently been the only wood at our command.

ESTIMATE OF COST (BASED ON ACTUAL WORK DONE) OF MILLING, ROASTING, CHLORINATING, ETC., AT DELORO, ONT.

Fifty tons per day.

LOADING AND HAULING from mines to mill (one shift, 10 hours)—	PER DAY.	PER TON, CRUDE ORE.
3 men, at \$1.50 each.....	\$4 50	
[N. B.—When mines are working, this will be done by two boys.]		
Oil, repairs, etc.....	50	
	<u>\$5 00</u>	\$0 10
MILLING (one shift, 10 hours)—		
7 men in mill, at \$1.50 each.....	\$10 50	
1 foreman, at \$2.....	2 00	
1 fireman, at \$1.75.....	1 75	
1 engineer, at \$2.....	2 00	
4 cords wood, at \$2.50 per cord.....	10 00	
Oil, repairs, etc.....	3 75	
	<u>\$30 00</u>	60
ROASTING (10 tons concentrates per 24 hours)—		
4 men, hoisting, feeding, etc., at \$1.50 each.....	\$6 00	
2 firemen, at \$1.75.....	3 50	
Half time of 2 foremen, at \$2.25.....	2 25	
1 fireman (steam at night).....	1 75	
6 cords wood, at \$2.50 per cord.....	15 00	
Oil, light, etc.....	1 50	
	<u>\$30 00</u>	60

CHLORINATION, PRECIPITATION, ETC.—

8 men at \$1.50	\$12 00	
Half time of 2 foremen	2 25	
Chemist	3 00	
Chloride lime, 550 lbs., at 2c per lb.	11 00	
Sulph. acid, 600 lbs., at 2½c per lb.	15 00	
Assay materials, precipitants, light, etc.	4 25	
	<hr/>	
	\$47 50	\$0 95
Office expenses, superintendent, repairs, etc.	12 50	25
		<hr/>
		\$2 50
		<hr/>

Mr. Koerner, then Acting Superintendent, reported the actual expenses during the last week in November, as follows :

THE CANADA CONSOLIDATED GOLD MINING COMPANY, I
DE LORO, ONT., January 26, 1883.

To R. P. ROTHWELL, Superintendent :

DEAR SIR: Below please find report in reference to the last week's work in November, after which the frost shut us down. I may mention that the putting in of the rolls and repairs of old ones occupied from October 20th to November 21st, so that the week before the frost came on was the only week for work I had :

Loading ore	\$92 00
Mill expenses	168 00
Furnace expenses (including chlorination)	78 00
Cutting and hauling wood	105 00
Acid and lime	110 00
	<hr/>
	\$554 00
Machine-shop	96 00
	<hr/>
	\$650 00
	<hr/>

Though the last item does not strictly belong to it, as it was on other work (construction account).

Number of tons put through the mill and concentrated, 270.

After the above week's work, the frost shut every thing up.

Very truly,

F. KOERNER,

Acting Superintendent.

The total pay-roll during November, is reported by the treasurer at \$3655.01. The above was so much of it as applied to treatment of the ore during the one week's run.

These items amount to \$2.41 per ton; adding repairs, office expenses, superintendent, and all other extras, esti-

mated very liberally at \$100 during the week, and the total cost would be but \$2.78 per ton.

The above figures are believed to be perfectly safe, and, as justified by actual work, many of the items are even excessive. If but 40 tons of crude ore produced 10 tons roasted concentrates, the total cost of treatment would be about \$3 per ton.

The mill has treated, since it was started, but 800 tons of crude ore, a portion only of which was concentrated. The following is a statement of the result :

ROASTED ORE.		TOTAL VALUE.	AVERAGE VALUE TAILINGS.	TOTAL VALUE TAILINGS.	NET GOLD OBTAINED IN SOLUTION.	PERCENTAGE EXTRACTED.
TONS.	AVERAGE VALUE PER TON.					
16¾	\$20 14	\$337 29	\$2 63	\$44 04	\$292 15	86·94
19½	32 59	635 50	2 88	59 57	579 93	91·24
47	55 58	2,611 83	2 67	97 16	2,514 67	96·28
59	24 11	1,422 49	1 41	78 91	1,344 86	94·54
142¼	\$35 19	\$5,007 11	\$1 95	\$277 68	\$4,731 61	94·50
1	45 21	45 21	45 21	45 21	.....	.....
6	34 21	205 11	not	assayed.	.....	.....
25	24 11*	*602 7.	"	"	.....	.....
174¼	.....	\$5,860 18	.....	.....	.....	.....

Each ton of these tailings was assayed separately. Summarizing, we find that the chlorination which at first yielded 86·94 per cent improved as work progressed, and especially as the ore was concentrated closer, until it reached 96·28 per cent as the average of 47 tons, having an average value of \$55.58 per ton. It will be noted above that one ton by some oversight was not chlorinated (probably was badly roasted, as was sometimes found to be the case before the second furnace was built), and was thrown out in the tailings. Omitting this one ton, the average of 142¼ tons assayed

* Estimated.

gave an average value of \$35.20 per ton; tailings, an average of \$1.95; percentage extracted and obtained in the liquor, 94.50 per cent. This is considered highly satisfactory for the commencement of work. In addition to the above 143½ tons, of which we have the assays of both ore and tailings, there were assayed and chlorinated six tons, average value \$34.21 per ton—total, \$205.11, but of which the tailings have not yet been assayed. Also, 25 tons chlorinated, of which no assays have yet been made, but which are estimated to average the same as the preceding 59 tons, namely, \$24.11 per ton. There are also 67 tons of roasted ore on hand, which may run the same as the 59 tons last assayed, but which, for greater safety, I count at \$20 per ton, and 18 tons raw ore ready to roast, counted safely at \$15. There is also a quantity of dust in the chambers, some ore lying about the mill, etc., all estimated at \$250. The whole summarizes as follows:

174¼ tons chlorinated, contained.....	\$5,860 18
67 " roasted, not yet chlorinated, estimated at \$20 per ton.....	1,340 00
18 " raw ore estimated at \$15 per ton.....	270 00
Dust in chambers, ore about mill, etc, estimated.....	250 00
Total, \$9.65 per ton of crude ore milled, or.....	\$7,720 18

From the above we see that, after deducting the heavy losses always incident to starting new works with men who never had any experience in the work, there have been obtained in the roasted ore about \$9.65 per ton of crude ore. The loss in concentrating has been heavy, though we have as yet no exact measure of it—not having the means to do every thing we desired or considered necessary.

We have about forty-five tons of crude arsenic on hand. This I had analyzed, and find it contains about 97 per cent of pure arsenious acid. This is remarkably pure, and, with refining, will produce a very exceptionally valuable product. This arsenic has a present net value of about \$20 a ton, or fully \$1 per ton of ore milled. When re-sublimed, this net value will be nearly doubled.

The above results may be summarized in the following table, which shows a fair estimate, based upon actual experience, of the profits obtainable in working this ore :

	PER TON CRUDE ORE.
Net amount of gold per ton of ore as mined, which is obtained in roasted ore, that is, after deducting losses in concentrating, handling, roasting, etc.....	\$9 65
Less loss in chlorination, 5 per cent.....	\$0 48
Less loss in precipitation, say 3 per cent.....	27
	75
	<u>\$8 90</u>
Net amount of gold obtainable.....	\$8 90
Net value of crude arsenic.....	1 00
	<u>\$9 90</u>
Cost of treatment.....	3 00
	<u>\$6 90</u>
Net profit realizable per ton, treating 40 tons per day, say..	\$6 90
Net profits realizable, milling fifty tons per day, \$7.40 per ton.	

These figures do not take account of the cost of mining, which will be about \$2.50 per ton; but this will probably be balanced by the reduced loss in concentrating, the saving of two per cent in chlorinating, and the greater profit from refining the arsenic, so that the final results may be counted as above.

With a treatment of only 40 tons a day, the net earnings should then be \$275 per day, or with 50 tons, \$370 per day, or, say, \$9500 per month, and for an expenditure of say, \$18,000, this output can be doubled, and arsenic refining-works completed.

The bullion actually produced has been only \$2148.65, and it represented in the above table \$3684 gold in the chlorine liquor, or, allowing 3 per cent loss in precipitation, say, \$3584, that should have been obtained. Of this difference, a certain amount will yet be recovered from some rich tailings from rechlorination of precipitate; gold in crucible bottoms, in slag, etc. The loss, which has been enormous, was probably due to careless handling, some leaks in new tanks, imperfect precipitation by sulphate of iron, and losses in melting. That they are not unavoidable is shown by the several well-

known experts, to whom the question was submitted and whose reports are appended.

The precipitation of the gold by filtration through charcoal appears to be entirely successful, and there are now some \$1800 in the charcoal. The experts generally, however, prefer precipitation by sulphide of hydrogen.

I beg to refer to these expert reports, but for convenience summarize them as follows :

Expert Tests on the Precipitation of Gold from this Chloride Solution.

Mr. William E. Gifford, chemist, finds that A_2S precipitated .0682 grm. gold per liter of solution. Ferrous sulphate, the same amount. That is the whole of the gold in the solution. Some lime was also precipitated with the gold by the ferrous sulphate. Charcoal also precipitated the whole of the gold without other substances.

Professor Koenig found ferrous sulphate precipitated .069 grm. gold per liter (threw down, also, some lime). Hydrogen sulphide, .0728 grm. gold per liter. $AlCl$ and ferrous sulphate practically same amount. The whole of the gold seems to be precipitated by these methods. Professor Koenig prefers an aqueous solution of hydrogen sulphide.

Mr. N. E. Riotte, metallurgist, New York, finds that hydrogen sulphide in gaseous form is much better than ferrous sulphate, which latter he finds does not precipitate all the gold.

Though the mines, the mill, the roasting-works, and the chlorination are all fully as satisfactory as was ever claimed for them, and the cost of treatment even with wages and materials far higher than when our estimates were made three years ago is scarcely higher than the figures then given, yet the time occupied in bringing the property into a dividend-paying condition has been far longer than anticipated, and the working capital necessarily increased in proportion.

No one can be more painfully aware than myself of the

difficulties and disappointments that have been the causes of this, and I desire here to state a fact well known to those of your officers and others familiar with the case, that the cost of and time occupied in the work done within the past eight months have been nearly double what they should and would have been had the stockholders promptly responded to the urgent appeals of their trustees and subscribed for the bonds when they were issued; indeed, the work during the past year has been carried on under extremely humiliating and expensive conditions, that probably no amount of salary alone would induce any one to submit to.

The company has had a most devoted and faithful servant in Mr. F. Koerner, Master of Machinery, who acted as superintendent during my absence in Europe. Much of the success of our concentrating and roasting-works is due to him. He has devotedly remained at his post under most disagreeable and unremunerative conditions, which also were such that professionally he could not do himself justice.

The chlorination department was under the charge of the company's chemist, Mr. Wilkins U. Green. Had the precipitation of the gold been as perfect as the chlorination, this department would have had a more satisfactory record, and the condition of the company would to-day have been very different from what it is.

I also desire to express my appreciation of the devotion and forbearance of our foremen, and many of the rank and file of our employés at Deloro, who continued working when the company already owed them some months' pay, and who, convinced of the ultimate success of our enterprise, are now waiting patiently for the resumption of work and the liquidation of their just claims.

RICHARD P. ROTHWELL,
Superintendent.

REPORT OF MR. F. KOERNER, MASTER OF MACHINERY.

WILKES-BARRE, PA., February 10, 1883.

R. P. ROTHWELL, Esq., Superintendent:

DEAR SIR: In compliance with your request for a *résumé* of the work at Deloro, as far as it was under my charge, I submit as follows:

After the new mill was started, toward the end of April last, and ore ground, it was found that it could not be roasted, for the reason that no draught could be made through the furnace and arsenic chambers; in fact, after several weeks' trial, the attempt had to be given up and an exhaust-fan put up to make the necessary draught.

With the fan in operation, it was found that, while a small quantity of ore could be roasted in the furnace, the draught had necessarily to be so sharp, owing to the smallness of the openings in the arsenic chambers, that most of the arsenic, instead of being lodged in the chambers, was carried through the fan and up and out of the chimney and lost. When the fact that the fan exerted a pull of five eighths of an inch water-gauge is remembered, an idea of the friction of the air may be formed.

Besides the loss of the arsenic, the fierceness of the draught carried fully 40 per cent of the ore back out of the roasting cylinder into the dust-chambers.

These causes made it necessary to stop all the work of grinding ore and roasting, and remodel the chambers. This was done by cutting the openings from one chamber to the other down to the floor, and also by making an extra opening in the cross-division wall of each chamber.

These changes were found effective, and were completed by the end of July last, when the boiler-house at the new mill took fire on August 6th. The necessary repairs of pipes and connections occupied three weeks.

In the mean time, gearing had been applied to the Cornish rolls, and their work became very successful. We were also erecting the masonry and brick-work for an additional roasting-furnace, which, when completed, toward the end of October, gave us entire control of the ore roasting, with a capacity of ten tons daily.

It was then found that it had become necessary to complete the putting in of the mill machinery by adding one No. 2 screen and putting in the second set of Cornish rolls and one new jig. After these additions, or rather after completing the mill so far, it was found that it would grind, screen, and concentrate the ore at the rate of from six to seven tons per hour, and that the furnaces would successfully roast the resulting concentrates.

We had by this time reached the beginning of December last. The weather kept continuously so cold—as low as 20 degrees below zero, Fahrenheit—that further work in the mill became impossible. Having arrived at this point, that is to say, when we could roast ten tons of concentrates, worth on an average from \$60 to \$70 per ton, it was found that the lime in the gold solution made the precipitation of the gold so difficult that only a few tons could be daily chlorinated.

Legal complications forced us to suspend work entirely, as to chlorination and roasting, for several weeks.

The substitution of charcoal filters for the ordinary process of precipitation by iron sulphate seemed, toward the end of December and beginning of January, to promise a way out of the difficulty.

While it can not be denied that a great deal of work has been done at Deloro, and many difficulties overcome, much more would certainly have been done but for the want of money. During the summer months, with new railroads building all around us, and the wages of our men in arrears, we were often so short of the necessary laborers that mortar-making, ore-loading, mill-work, etc., had to be done in rotation by the same men; and, worse than that, the men's wages being in arrears, they worked for us as a favor, as it were, and discipline became exceedingly difficult, if not impossible.

But the want of money affected the business as seriously, to say the least, in other ways. When the mason work for the new roaster was ready and every thing else complete, the roaster itself could not be put in place for want of the necessary outside rings and castings which were lying at the railway station at Sterling, and could not be got for want of money to pay the freight. Three weeks were lost with this single item.

The pipes for heating the mill and by that enabling us to go on working and producing at least \$2000 profits per week, were lying in the Custom-House at Belleville; but there was no money to pay the charges.

I am writing this on a bed of sickness, in the intervals when I am free from pain, and I am aware that my report is not as full as it should be and would have been under other circumstances.

Respectfully submitted,

(Signed) F. KOERNER,

Master of Machinery.

REPORT OF M. WILKINS U GREENE, CHEMIST.

THE CANADA CONSOLIDATED GOLD MINING COMPANY, }
 DELORO, ONT., January 29, 1883. }

R. P. ROTHWELL, Esq., Superintendent:

DEAR SIR: In your communication of the 27th inst., you requested me to make a report, as chemist to this company from July 24th, the time I entered on that position, to the present date.

I was engaged by the company through you as chemist and assayer, but was never placed in charge of the chlorination department. After I had been here a short time, on the absence of Henry Bost, I started to run the chlorinator, and have since continued in that capacity.

As you well know, the lime that occurs in the ore has been a source of endless trouble, as most precipitants of gold would precipitate the lime also. In order to separate the lime from the gold, several methods have been tried.

First. On experimenting, I found that sulphuric acid would crystallize the lime out of the gold solution, so solutions from several tons of ore were treated with sulphuric acid, and the lime allowed to crystallize out; the gold solution was then drawn off, and the gold precipitated with sulphate of iron. But still some lime was found with the gold, due to the sulphuric acid not affecting some hyposulphate of lime which was in the gold solution.

By this method most of the gold was extracted up to the time you sailed for Europe.

As the quantity of sulphuric acid required to precipitate or rather crystallize the lime was large, it was thought advisable to try some other process.

On my return from New York, after you left, I continued chlorinating. The gold solution accumulated, filling all the tank-room, before I could discover the best method to try next. As I would have to stop chlorinating if some of the solution was not removed, and as stopping was against the orders of Mr. Loveridge or Mr. Koerner, I tried the following method:

At this point I wish to say that I had commenced on my return to carry out your orders in regard to keeping the liquor for a certain number of tons separate in a tank; but as the tank-room was full, and having no means of getting rid of the liquor from each tank by itself, I was obliged to use the following process:

To a tank of solution was added sulphate of iron until a very small quantity of gold was precipitated, and nearly all the lime as a sulphate. This was allowed to settle; the solution containing the gold was placed in another tank, and sulphate of iron added.

Into the tank containing the lime and a little gold, more gold solution was placed, which dissolved the gold already in the tank, and the same process was repeated. My intention was to make a filter below these lime-tanks, and after dissolving the gold from the lime, to filter the gold solution which might be with the lime, wash it and throw it away; in this manner get rid of the lime. But the necessary supplies to make this filter I applied for and they were promised me, but never sent. This left me in a very bad position, as, when the process was given up, it left three tanks half full of lime holding some gold. The process would have been, I think, a success if I could have carried it out as I desired to, but I was ordered by Mr. Koerner to get a brick out in a week's time. In order to do this, I had to precipitate all the liquor which had not been treated as above with sulphate of iron, and rechlorinate the bulky precipitate thus produced. Of course, this time, as before, I was unable to make a clean-up, owing to the gold in the tanks with the lime which I had not time to separate.

As in rechlorination some lime went through the filters, some of the strong gold solution was left in the tank and was afterward passed through the charcoal filters.

On or about November 21st, 1882, at the one hundred and thirty-seventh ton chlorinated, the charcoal filters were started, which, I was told by Mr. Loveridge, was an experiment made by the company and not by me. The liquors from chlorination have been since passed through them.

In order to get the gold which was in the tanks I spoke of, with the precipitated lime, I was obliged to pump some gold solution, strong in chlorine and stir the lime up with it, as by this means the precipitated gold would be dissolved. The lime was then allowed to settle and the gold solution taken off and passed through the charcoal filters. The remaining lime was placed on a filter and washed till no gold showed itself.

The charcoal filters seem to have done very good work, precipitating the gold and not the lime; very strict watch has been kept on them night and day.

About January 10th, the eight upper barrels of the filter were taken down and replaced by fresh ones that the gold might be extracted. This charcoal was started burning on January 26th, 1883.

It was my desire through all this time, covering a period of six months, to make a complete clean-up, in order to ascertain how the bullion and assays agreed; but as I received orders to get a brick out in such a limited time I was unable to do so, much to my regret. I am sure it would have saved the company more than it has cost them.

There have been several channels through which solution has been and might have been lost.

One or two of the tanks had been lined with very thin lead, and others with very poor lead, through which the solution would eat holes and thereby a loss would occur; all of which was repaired as soon as discovered. The rubber hose, which was used to convey the solution from the filter to the col-

lecting tanks, was very poor, three-ply pipe. It would crack and holes appeared in it. I asked for some other, better, explaining the great necessity of it, but it was never supplied.

In regard to the assays and sampling: Every 200 pounds was sampled and the samples from each ton assayed (duplicated). By referring to the assay-book, you will see that in some cases the duplicates disagreed greatly on account of coarse gold: an average was taken, of course. That average might have been too high or too low in many cases. Mr. Santa Maria's assays were done by mixing three tons together (samples), which I do not think would give correct results, as they were in the richest concentrates containing coarse gold, and would differ considerably. These would make the results of the assays differ from the bullion extracted. I have been, during my stay here, under orders from yourself, Mr. Koerner, and Mr. Loveridge, which in many cases have conflicted with each other, placing me in a very undesirable position. I have endeavored as far as possible to have the approval of one of the above-named to every detail of working I have undertaken.

Yours respectfully,

(Signed)

WILKINS U. GREENE.

CHEMISTS' REPORTS UPON THE PRECIPITATION OF GOLD FROM CHLORIDE SOLUTION.

R. P. ROTHWELL, M.E., Superintendent :

STR: Having examined the sample of gold solution from chlorination of ore, received from you February 3d, I will endeavor to answer the questions there put to me :

First. Whether sulphureted hydrogen will precipitate all the gold free from other substances, and at what cost ?

(The question being raised whether the ordinary reagents precipitate all the gold from this particular solution, it was obviously inadmissible to adopt any of them as a standard, and it became necessary to resort to evaporation, smelting, etc., to destroy any supposed peculiar combinations, however well convinced I might be of the reliability of these reagents)

I precipitated a sample of the solution by sulphureted hydrogen, and obtained gold amounting to .0682 gram per liter. I could obtain no more gold from the solution, and concluded that the precipitation was complete. This precipitate is practically free from foreign matter, except a little sulphur, which separates after the gold, and helps to collect the latter. The quantity of sulphur would be greater if the solution contained more iron and free chlorine. The cost of this method is difficult to estimate precisely, but it need not be much greater than the method by sulphate of iron, perhaps no greater.

Second. "Does charcoal filtering very slowly take *all* the gold out?" After filtering a quantity through charcoal, I have not found any gold remaining in the solution, except traces proportionally insignificant, and up to a certain point fail to detect *any*. I have not been able, in the time allowed, to determine, even approximately, the limit to the power of the charcoal to remove gold, etc., and this limit will depend greatly on the composition of the liquid at different times, on the amount of iron, free chlorine, etc.

Third. "Do you know any thing which will cheaply prevent the lime, etc., from precipitating when the gold is precipitated by sulphate of iron?" I think of nothing practically applicable, at present.

Fourth. "Does sulphate of iron precipitate all the gold from this solution along with or without lime, etc.; also, after filtration through charcoal, should there be any gold unprecipitated, will sulphate of iron then precipitate it?" If sulphate of iron fails to precipitate the gold under these circumstances it must be due to some change in the condition of the solution, or of the state of combination of the gold by the charcoal. It is highly improbable that any such change can occur as to prevent the action of sulphate of iron, and to determine this point definitely it is necessary to continue the filtration until the absorption by the charcoal ceases to be complete, and then test the action of sulphate of iron. I have not had time to continue it so far, but on *adding* a minute quantity of chloride of gold to the liquid after passing through charcoal, I obtained the normal result.

By precipitating a sample of the original solution by sulphate of iron, I obtained gold amounting to .0685 gram per liter. I have been unable to find gold remaining in the solution, and conclude that the precipitation is complete. I consider the quantity obtained as identical with that obtained by sulphureted hydrogen, as the sample used was only a fraction of a liter (100 c. c.), and the error in manipulating this quantity of gold might amount to the difference, which was less than one twentieth milligram. The action of sulphate of iron is, first, to color the solution purple with finely-divided gold. Afterward, especially when agitated, the gold aggregates to some extent, and the solution loses its color; finally, a little sulphate of lime separates and subsides with the gold. If the solution is not slightly acidified, a little basic salt of iron will separate also.

Fifth. "Do you know of any other cheap method of getting all the gold without lime, etc.?" A solution of protochloride of iron, made by dissolving scrap-iron in muriatic acid may be used, and will precipitate the gold without lime, and, I think, in a state of great purity. The cost of this would be probably about the same as sulphate of iron.

Very respectfully,

WILLIAM E. GIFFORD.

UNIVERSITY OF PENNSYLVANIA,
WEST PHILADELPHIA, Feb. 13, 11 P.M., 1883. }

R. P. ROTHWELL, Superintendent :

DEAR SIR : You sent me about 1½ liters of liquid, said to have resulted from the chlorination by the Mears process, after a previous roasting of the Canada Consolidated Gold Mining Company's ore. By your statement this liquid contains per liter :

Arsenic acid	= 3·600
Hydrochloric acid	= 5·880
Sulphuric acid	= 0·800
Lime	= 0·900
Ferrie oxide	= 0·110
Gold	= 0·057

It is further stated that, upon adding ferrous sulphate to this liquid, an unmanageable voluminous precipitate will form, and that this precipitate is gypsum, containing the gold. Also, that a precipitate of lime and magnesia sulphates will form, when sulphuric acid be added alone to the liquid. A sample of such precipitate was sent me. You propose the following questions :

1st. How can the formation of the unmanageable precipitate be avoided ?

2d. Does this precipitate carry down all the gold with it ?

3d. Which other precipitant might be used, so that it would not take down any impurity with the gold ?

In order to find answers to these questions, the following experiments were made. It may here be mentioned that a larger quantity of liquor, so that one liter could have been used for each test, would have lessened the error of manipulation ; but, even as it is, the results are quite trustworthy, and enable us to base technical reasoning thereupon :

First Experiment.—To 500 cc. of the liquor were added 10 cc. of dilute sulphuric acid = 1·73 gr. of sulphuric hydrate. From a burette was dropped a solution of 1 crystallized ferrous sulphate in 10 water. After the addition of 3·6 cc., the yellow color is completely discharged, and at 4 cc. the liquid fills with brown precipitate (gold). No precipitate of gypsum was noticed for thirty minutes, but next morning, when the liquid was quite clear, gypsum had crystallized. It was all brought upon a filter, no more water being used than necessary to clean the beaker-glass. After ignition it weighed 0·663 gr. It was treated with aqua regia and precipitated by H₂S. The ignited precipitate weighed 36·3 mgr. Packed with borax into a paper, it was fused to a button, flattened upon the anvil, and weighed 34·5 mgr. of fine gold. By the equation $(\text{AuCl}_2)_2 + (\text{FeSO}_4)_6 = \text{Au}_2 + (\text{Fe}_2\text{S}_2\text{O}_7)_3 + (\text{HCl})_6$, 392 gold require 1668 parts of cryst. iron sulphate; 34·5 mg. Au therefore $34\cdot5 \times 4\cdot25 = 146\cdot6$ mgr. In the above 4 cc. there are contained 400 mgr. of sulphate, nearly 2·7 times

the required quantity. It will be noticed that this experiment yielded 69 mgr. of Au per liter, against 57, as given in the analysis. Sulphide of hydrogen added to the filtrate gave no *browning*, but only opalescent yellow after a few minutes (arsenic).

Second Experiment.—To 250 cc. of the liquor was added from a burette a fresh saturated aqueous solution of hydrogen sulphide. The yellow color disappears after the addition of 1 cc. Then a brown color appears, and at 4 cc. the color in reflected light is nearly black. Stirring vigorously coagulates the gold sulphide. To be sure of a sufficiency, 6 more cc. were added—10 in all. After thirty minutes, the liquid was still very brown in transmitted light from numerous floating particles; only 50 cc. were passed through a filter (filtrate absolutely colorless and unchanged by more than H_2S); the bulk was left standing over night, to see how far a complete settling would take place. In the morning, after fourteen hours' standing, the liquid was still brown, nearly as much as the evening before. Settling could not be relied upon, and filtration is necessary. After collecting the precipitate upon filter, (double paper always used), it was washed with about 40 cc. of water, containing a few drops of dil. HCl. By ignition obtained 20 mgr, fused to a button with borax and cleaned by flattening, weighed 18.2 mgr, equal to 72.8 mgr per liter, against 57 mgr of the analysis, and 69 mgr by previous experiment.

Third Experiment.—To 250 cc. of liquor added first 3 cc. of dilute HCl. (1 in 10); then the 0.1 ferrous sulphate from a burette. After the yellow color was faded, a dirty white flocculent precipitate begins to form, which rapidly assumes a deep blue purple color on addition of a second cubic centimeter. The end of the reaction can not be noted here as well as in preceding experiments. But since, in Exp. 1, 4 cc. had been sufficient for $\frac{1}{4}$ liter, I added here 2 cc. for $\frac{1}{4}$ liter. The greater part of this precipitate settles rapidly; the liquid, however, retains its purple color from suspended particles. Consistency of precipitate is very fine, compact, flocculent. After four hours' standing, the liquid was as purple as after the first half-hour. It filters very easily through a double paper. When all was collected, I washed with about 50 cc. of water; then I filled the filter with 10 cc. of 0.1 hydrochloric acid (cold), and a yellow liquid ran from the filter, while the latter covered itself with brown gold. Washed once, then put on 10 cc more of 0.1 hydrochloric acid, and finished by washing with 50 cc. of cold water. Ignited precipitate and ashes weighed 19.2 mgr., fused to a button weighed 18.8 mgr., the highest result of the three experiments. I am not certain that this button was quite fine; it may contain a small quantity of arsenic, and it will yet be assayed for purity. But certainly this trial gave as much gold as the hydrogen sulphide. I attribute that mainly to the nature of the vehicle inclosing the gold and leaving less

chance for a mechanical loss, sticking to glass surface or passing through filter-paper.

In the acid filtrate from the gold I found—

Arsenic acid	— 0.0588 gr.
Ferric oxide	— 0.0340 gr.
Calcium sulphate	— 0.0065 gr.

We have here the atomic ratio of $\text{As}_2\text{O}_3 : \text{Fe}_2\text{O}_3 = 5.0 : 4.25$, that is, a true basic iron arseniate, mixed with about 7 per cent of gypsum. This is the composition of the precipitate I anticipated when you wrote that it was chiefly a mixture of lime and magnesia sulphate. This observation is of considerable scientific interest. We have here a true iron purple of cassius; that is, this purple is not a chemical combination of stannic hydrate and gold, but a mere mechanical mixture; it requires only an enveloping white flocculent vehicle to bring out the metallic gold with a purple color. I reserve the right to make a public announcement of this observation. The precipitate can only form in a perfectly neutral or nearly neutral solution, such as your liquor is. By these experiments, I believe that the two first questions have been satisfactorily answered. But of this anon.

It remained now to determine how thorough, by each precipitant, the gold will be removed from the solution. A solution was required as nearly as possible like the one in question, containing a known quantity of gold. Accordingly four liters were made of such a liquid by the analysis, although there were some grave doubts regarding its accuracy. For, if we calculate the acids and oxides as to their combining weights, it follows that $\text{CaO} : \text{As}_2\text{O}_3$ as 3.8 : 1.1, as 4 : 1, which is chemically impossible. The ratio should be as 1 : 1. This was proved by the fact.

Solution: 12.2 grs. of white arsenic were oxidized by aqua regia, evaporated to dryness, 60 grs. of marble-dust dissolved in HCl, and boiled so that a residue remained; 7.2 gr. magnesium carbonate likewise. 0.31 gr. metallic iron oxidized and evaporated, and 5 cc. of the dilute sulphuric acid added. When the iron and arsenic acids came together, they precipitated, and HCl had to be added to maintain solution. The gypsum dissolved completely in 3 liters of water: 240 mgr. of fine, precipitated gold were then dissolved and mixed with the other ingredients, so that the whole measured just 4 liters. In one liter there is, hence, 60 mgr. of gold. The color of solution is light yellow, not the rich brown yellow of the solution you sent. I do not know at present the cause for this difference, unless it be the greater neutrality of the latter, caused by the pressure in the chlorinator. This must be the cause, because, with my solution, I could not obtain the purple precipitate.

The following tests were made:

Fourth Experiment.—To 500 cc. of solution were added 3 cc. of concent. hydrochloric acid, and 10 cc. of 0.1 ferrous sulphate. Did at first

not seem to precipitate; but standing over night, a brown sediment was observed. Filtered and washed with 40 cc. of water, and 3 of 1.0 HCl. Ignited, weighed 31.85 mgr.; fused with borax, the button weighed 27.7 instead of 30 mgr.

Fifth Experiment.—To 500 cc. of solution were added 6 cc. of ferrous solution and no acid whatever. Liquid became colorless when 2 cc. had been dropped into, and brownish turbid when 4 had been added. Total equals 6 cc. After washing with water without acid, the ignited precipitate weighed 30.0 mgr.; fused with borax, the button weighed 27.85 mgr.

Sixth Experiment.—To 500 cc. of solution added 5 cc. of fresh saturated chlorine water. The mixture smelled very strongly of chlorine. Upon the addition of 4 cc. ferrous solution, color disappeared. But even after adding 40 cc. of ferrous solution in all, no turbidity was visible. Stood twenty hours. Now the gold could be seen among the crystals of gypsum, of which about 0.5 gr. had fallen out; it dissolved in 250 cc. of water. Ignited, the precipitate weighed 36.4 mgr.; the button, fused with borax, weighed 28.4 mgr. The presence of free chlorine, nor the addition of large excess of ferrous sulphate, interferes, therefore, with the precipitation of the gold.

Seventh Experiment.—To 500 cc. of solution, at a temperature of 10° C. were added 6 cc. of fresh saturated solution of H₂S. Precipitate does not coagulate so rapidly as when previously the temperature had been about 17° C. It stood twenty hours, had settled completely and filtered well. In the perfectly colorless filtrate, H₂S caused no coloration. Ignited, the precipitate weighed 38.8 mgr.; the button, fused with borax, weighed 29.85 mgr., instead of 30 mgr.

Eighth Experiment.—To 500 cc. of solution added 6 cc. of chlorine-water and 14 cc. of solution H₂S, was allowed to stand for two hours, then filtered, the great bulk having settled in flocculent state. Precipitate ignited gave 34.4 mgr; the fused button weighed 29.15 mgr. instead of 30 mgr.

NOTE.—There is reason to believe that a loss occurred in the fusing operation.

Now, it seems to me clearly proved that sulphide of hydrogen precipitates the gold completely (Experiment Seven), and that the purple precipitate gave a higher result even than the sulphide of hydrogen, which I only attribute to the mechanical condition of the precipitate. Sulphide of hydrogen takes down no impurities if applied in proper quantity, which is best done when water is charged with that gas. Acid is required to make H₂S and acid also to decompose the purple. The latter offers better guarantee against loss, and requires no special apparatus. It will work with your solution, because this is very neutral. If not more of the iron salt is added than necessary, no gypsum of any consequence will fall out. Any workman of average intelligence can readily

be trained to perform the work. Let him take a liter of the liquor after the latter is thoroughly mixed in the tank. Have the copperas dissolved 1 in 10 water, and let him add from a burette until the purple forms, then let him pour some of liquid upon a double filter, and try with H_2S water, if a browning occurs; if not, he has added enough of the iron salt; if, then he adds a few drops more. This operation will not take more than ten minutes. If now the iron solution be in a cylindrical tank, with a rod in it graduated to one quarter liters, he can let in the proper quantity into the precipitate tank without any trouble. To decompose the purple, you use warm one tenth sulphuric acid, and less acid will be required than if dry hydrogen sulphide be generated for the purpose. I do not advocate this plan as a pet one, because the sulphide of hydrogen is equally good, but requires the attendance on a special apparatus. Should you decide upon the latter method, I would advise the use of saturated water, which you get by fitting a good-sized iron stovepipe, barred inside and outside twenty feet high, filled with coke of nut size, over which the water trickles against the current of the gas. If there be no free chlorine or only little, six liters per 500, or twelve per cubic meter, will be quite sufficient. But the attendant will have to test a liter exactly as before with the iron solution; and good stirring is required. If you desire, I will furnish you with a detailed diagram and measures for the apparatus, as I should build it. But you must let me know the daily production in liters.

To do any thing with the roasted ore, I have not had time to attend to that yet. I shall continue, also, my experiments from a scientific stand-point, operating with larger quantities, to get a yet truer value of ferrous sulphate versus H_2S .

Your telegram asking for my results to-day was received at noon. But having to attend to teaching duties, I could not write down my notes. Yours truly,

GEORGE A. KÖNIG, Ph.D.,
Prof. of Metallurgy.

P. S.—No elevation of temperature was made use of in any of the experiments. The action of SO_2 was not mentioned, because it acts with satisfaction only at the boiling-point. The filtrates were always tested for gold.

NEW YORK, February 7, 1883.

R. P. ROTHWELL, Superintendent :

SIR :

First Sample.

One ton of liquor equal to 31.7 cubic feet of liquor, contains, according to evaporation test, 1.94 ounce gold, equal to \$40.19 (equal to

66·5 grams gold per 1000 kilos liquor). By precipitation with sulphureted hydrogen, from crude solution, 2 ounces gold, equal to \$41.34 (equal to 68·56 grams per 1000 kilos), can be extracted.

Second Sample.

One ton of liquor gives 2·19 ounces (75·07 grams) gold, equal to \$45.96, by precipitation with sulphate of iron ; and 1·95 ounces (66·84 grams) gold, equal to \$40·30, by precipitation with sulphate of iron from a boiled solution ; and 2·43 ounces (equal to 83·29 grams) gold, equal to \$50.23, by precipitation with sulphureted hydrogen from the cold solution.

Slight inconsistencies above to be noted, are to be placed to the account of "limit of accuracy."

OBSERVATIONS.

1. Sulphate of iron does not precipitate all the gold, especially not if the solution still contained some free chlorine. Evaporation test showed gold still present in precipitated liquor.

2. Settling and filtration are very slow, perfect filtration almost impossible.

3. Cost about the same as sulphureted hydrogen.

4. Gold is mixed with some lime, but more alumina, and product is difficult to melt.

5. Sulphureted hydrogen precipitates the gold perfectly, quickly, and in a floccular state, making filtration easy. The gold is pure sulphuret, with possibly a little sulphuret of arsenic, and easily smelts to pure gold. After filtration, the solution can be saturated with sulphureted hydrogen, and thus a heavy percentage of beautiful sulphuret of arsenic (auri pigment) obtained, which may possibly pay for the entire operation.

Test in filtering through charcoal and electrical test, and estimate of cost will follow to-morrow.

Solution contains but very little lime. The alkaline earth is alumina. (Probably as a lime, iron and magnesia alum, or even arseniate.)

The analysis shown must be wrong. In sample No. 1 the percentage of gold is but 0·006 per cent ; in sample No. 2, 0·0075 per cent ; while the French analysis calls for _____ per ton of liquor.

Very respectfully,

MATHEY & RIOTTE.

NEW YORK Feb. 14, 1883.

SIR : I have just completed the experiments with the gold solution, and the possibility of precipitating by electricity. I made two trials. One to collect the gold on the anode pole in a bath of mercury, and another to simply precipitate in the solution.

The first trial gave results that were very accurate, but too much time was required. The little gold amalgam was easily handled, and the solution needed no filtering.

The second trial was made with a porous cup and platin wire anode. The gold was quickly precipitated, but the collection necessitates filtering, or decantation and filtering, and the gold is in a very fine state.

Taking the different methods, I should say that the choice fell between two—precipitation with sulphureted hydrogen (generated from paraffine and sulphur), and by means of a dynamo.

The plant for the first is very inexpensive, the cost of sulphur and paraffine nominal, and the possibility of making the by-products (realgar) profitable good ; filtering easy and perfect. The cost of a dynamo is at least \$1000. Running cost very little, but filtering and collection difficult.

I should counsel you to make a trial with sulphureted hydrogen before all others.

Very respectfully,

E. N. RIOTTE, for
MATHEY & RIOTTE.