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THE RUSSELL PROCESS

AT THE YEDRAS MILL.

By ROBERT F. LETTS,
LATE SUPERINTENDENT OF MILL.

The Russell Process was introduced at the Yedras Mill (Anglo-Mexican Mining Company) in November, 1887, and has been in continuous use since then, having superseded the old leaching process which had been previously employed in the treatment of this ore. The object of this article is to compare these two processes, as well as to give such statistics on mill work, results obtained and expenses, as will be of general interest, without going too much into the technical details of the two processes.

The statistics here given have been accumulated during my connection with the Anglo-Mexican Company, extending over a period of six years, both before and after the introduction of the Russell Process, and the results here given cover not only the treatment of Yedras ore by that process, but also the re-treatment of all the old tailings which had previously been produced by the old leaching process.

The metallurgical history of the Yedras mill is as follows :

Smelting being economically and metallurgically out of the question, it was originally intended to work Yedras ore by roasting in Bruckner furnaces (four of which were erected at the mill) and treatment by amalgamation.

But it was soon discovered that neither these furnaces nor the amalgamation process would work on this ore. Not only was it impossible to obtain sufficiently good roasting results in the Bruckners, but then the ore was not in suitable condition for the subsequent treatment. Long reverberatory furnaces were therefore adopted for roasting and the old leaching process for the extraction of the silver.

This course was pursued for about three years, during which time I suppose the extraction of silver did not average over 65 per cent. of the value of the roasted ore.

In order to increase the extraction the Russell Process was introduced. The result, the first three months, as shown by the report of the superintendent of the mill, was a saving at the rate of \$100,560 U. S. coin per year,* the gain in extraction by the use of the Russell Process being 17.47 per cent. of the value of the ore more than could be obtained by the old leaching process. These comparative results

* NOTE —In this and subsequent statements the royalty for use of process is omitted.

were obtained by running the two processes side by side on the same ore for three months. Subsequent tests showed similar results, and are given in the superintendent's reports at the end of this article.

The property of the Anglo-Mexican Mining Company is situated on an eastern spur of the Sierra Madre mountains in the state of Sinaloa, Mexico, and can be reached from Jimenez, in Chihuahua, by stage to Parral, and then by mule for eight to ten days over a mountainous trail to Yedras.

The mill plant consists of

- 2 rock breakers,
- 2 shelf ore dryers,
- 1 shelf salt dryer,
- 40 ore stamps,
- 5 salt stamps,
- 8 reverberatory furnaces,
- 14 ore leaching vats, 11 ft. 8 in. diameter, by 5 ft. 2 in. high,
- 2 wash water precipitating tanks, 21 ft. diameter, by 5 ft. high,
- 2 solution precipitating tanks, $14\frac{1}{2} \times 9\frac{1}{4}$,
- 3 solution precipitating tanks, $10\frac{1}{2} \times 9\frac{1}{2}$,
- 1 solution storage tank, $11 \times 8\frac{1}{4}$,
- 2 solution storage tanks, $9 \times 4\frac{2}{3}$,
- 1 sulphide sump tank, $7\frac{3}{4} \times 4\frac{1}{3}$,
- 1 sodium sulphide mixing tank (iron) 3×7 ,
- 2 sodium sulphide storage tanks (iron) $3\frac{1}{2} \times 5$.

The variations in size of the tanks and vats is explained by the fact that the leaching department was made to suit existing circumstances as to grade and area, otherwise the ore vats would have been made larger and the tanks generally of more uniform size.

The leaching department at Yedras has a capacity of about 60 tons per day, occupying a building 60x100 feet.

The following are two analyses of Yedras ore, representing the averages of the ore treated at different periods :

	No. 1.	No. 2.
Carbonate of lime.....	33.78	46.50
Silica	15.13	25.00
Iron	17.33	9.80
Sulphur.....	13.31	12.50
Arsenic ..	9.82	2.50
Zinc	4.92	—
Lead.....	1.78	—
Magnesia	2.58	—
Alumina	1.35	—

No. 2 is an analysis of the average battery sample for one month. The composition of the ore varies greatly. A couple of months after

the above analysis No. 2 was made, the battery samples for several weeks had 4 per cent. zinc, and two months later contained great quantities of antimony.

Table I. gives general mill statistics, representing the average for five years.

TABLE I.
CRUSHING AND ROASTING.

Year.	Mesh of Screen on Battery.	Rate of Crushing per Stamp per Day.	Per Cent. of Salt used in Roasting.	Wood used per Ton in Roasting.
	Mesh.	Tons.	Per Cent.	Cords.
Nov. 1888, to Sept. 1892	22	2.8	6½ to 7	0.23

The rate of crushing per stamp given in the above table is for twenty-four hours, but the battery is not usually run at night.

TABLE II.
GENERAL LIXIVIATION STATISTICS.

Year.	Net Weight of Vat Charges	Depth of Charges before Leaching.	Depth of Charges after Leaching.	Filtering Rate per Hour.	Strength of Stock Solution in Hypo.	Strength of Extra Solution in Blue Stone.	Temperature of all Solutions.
	Tons.	Inches.	Inches.	Inches.	Per Cent.	Per Cent.	° Fah.
1888	16 to 18½	62	53	4.38	1.89	0.69	Cold or 40 to 60
1889	16 to 18½	62	53	3.34	1.43	0.69	
1890	16 to 18½	62	53	3.63	1.40	0.69	

The mill solutions at Yedras are never used warm, cold solutions giving equally good results.

TABLE III.
LIXIVIATION STATISTICS.

DEPTHS AND VOLUMES OF WATER AND SOLUTIONS, AND TIME OF LEACHING.

Year.	1st Wash Water.			1st Ordinary Solution.			Extra Solution of the Russell Process.		
	Time.	Depth	Volume per Ton	Time.	Depth.	Volume per Ton	Time.	Depth.	Volume per Ton.
	Hrs.	In.	Cub. ft.	Hrs.	In.	Cu. ft.	Hrs.	In.	Cu. ft.
1888	10.72	43.24	23.2	25.63	95.37	51.3	19.02	24	13
1889	12.52	41.81	22.5	32.09	93.45	50.3	20.77	24	13
1890	12.24	40.25	21.6	43.50	149.20	86.0	19.07	24	13

The twenty hours time given for "extra solution" includes twelve hours during which the solution stands in the ore. In the case of the wash waters and ordinary solutions the liquid is continually running through the charge.

TABLE III.—CONTINUED.

LIXIVIATION STATISTICS.

DEPTHS AND VOLUMES OF WASH WATERS AND SOLUTIONS,
AND TIME OF LEACHING.

Year.	Second Ordinary Solution			2d Wash Water.			Total Times, Depths & Volumes.			
	Time.	Depth.	Volume Per Ton.	Time.	Depth.	Volume Per Ton.	Total Hours Leaching.	Total Depths of solution.	Total Volumes of Solutions Per Ton.	Total Water Per Ton.
	Hours.	Inches.	Cu. Ft.	Hours.	In.	CuFt	Hours.	Inches.	Cu. Ft.	Cu. Ft
1888	54.20	212.27	114.1	7.34	24	13	116.91	331.6	178.4	36.2
1889	57.17	176.41	94.3	10.38	24	13	132.91	293.9	157.6	35.5
1890	54.27	193.40	140.0	8.72	24	13	137.80	366.6	203.0	34.6

The volume of water per ton, referred to in the last column of the above table, represents the total quantity used per ton in leaching. The solutions being used over and over again indefinitely, no water is required for them except at the first starting of a mill, when they are made up once for all. If the rate of leaching at Yedras were faster, as at the Aspen mill in Colorado, where, I understand, the leaching rate is about 14 inches per hour, instead of three as at Yedras, the time occupied in treating a charge would be much reduced. Just so much solution must pass through the ore to accomplish the work, but, with the exception of the extra solution which is allowed to stand twelve hours, all the wash waters and solutions do just as good work running rapidly through the charge as slowly. For a four times as rapid rate of leaching the time of treatment of a charge would be reduced about two-thirds.

TABLE IV.

CHEMICALS USED PER TON OF ORE.

Year.	Hyposulphite.	Blue Stone.	Caustic Soda.	Sulphur.	Total Chemicals per Ton.
	lbs.	lbs.	lbs	lbs.	lbs.
1888	1.07	7.02	5.12	3.97	17.18
1889	0.82	5.62	3.13	2.69	12.26
1890	0.74	3.85	2.69	1.86	9.14
1891	1.31	6.02	4.23	2.92	14.48
1892	0.85	6.16	3.64	2.50	13.15
Average	0.96	5.73	3.76	2.79	13.24

Owing to distance from railroad the price of chemicals per pound at Yedras is, of course, considerably greater than at any place in the United States or at most localities in Mexico.

In the following table, and throughout this article, United States money is used, as the value of Mexican silver coin varies according to the price of silver.

The average cost of chemicals per pound at Yedras for the last three years is as follows :

Hyposulphite of soda.....	8.0 cents.
Blue stone.....	10.0 cents.
Caustic soda.....	9.1 cents.
Sulphur.....	7.1 cents.

No soda ash (sodium carbonate) is used at Yedras, as there is usually no lead in the ore.

The total cost of all chemicals at Yedras in 1890 was 3.6 cents per ounce of silver produced. Of the copper used in the form of blue stone, about 50 per cent. remains in the ore.

TABLE V.

COST OF CHEMICALS PER TON OF ORE.

Year.	Hyposulphite.	Blue Stone.	Caustic Soda.	Sulphur.	Total Cost of Chemicals per Ton of Ore.
	Cents.	Cents.	Cents.	Cents.	Dollars.
1888	8.7	70.2	46.5	28.2	1.54
1889	6.6	56.0	28.5	19.1	1.10
1890	6.0	38.5	24.5	13.2	0.85
1891	11.1	63.2	40.2	21.9	1.36
1892	7.6	70.8	38.3	21.2	1.38
Average	8.0	59.7	35.6	20.7	1.25

In the following table are given the assay office results by both the old leaching process and the Russell Process, and the mill results obtained by the latter during the past year. The assay office results are, of course, the standard up to which each of these processes is expected to work in the mill. As shown in the tables the Russell Process in the mill is a little above its standard. On each charge of ore the old process is used first, extracting what it can, and then the Russell Process follows it. But, except when a comparative mill run between the two processes is made, the results of which are given further on, the tailings are not sampled after the old process and before the Russell Process, but only when each charge is entirely finished. Consequently the mill results by the old leaching process are not given in this table.

TABLE VI.

ASSAY OFFICE AND MILL RESULTS FOR 1892.

Month.	Extraction by Old Process in Assay Office.	Extraction by Russell Process in Assay Office.	Extraction by Russell Process in Mill.	Russell Process in Mill compared with same Process in Assay Office.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
January	71.28	84.75	80.45	- 4.30
February	77.73	85.77	84.25	- 1.52
March	78.26	85.96	86.33	+ 0.37
April	78.72	87.01	87.94	+ 0.93
May	75.62	86.98	88.53	+ 1.55
June	69.52	87.30	88.61	+ 1.31
July	70.29	85.61	86.26	+ 0.65
August	69.51	86.88	89.65	+ 2.77
September . . .	69.43	87.55	90.55	+ 3.00
October	61.87	86.32	89.88	+ 3.56
November . . .	61.44	87.24	87.61	+ 0.37
December . . .	62.42	84.68	91.24	+ 6.56
Average	70.50	86.30	87.57	+ 1.27

In Table VI the - and + signs indicate by how much the Russell Process in the mill fell below or exceeded its standard, i. e. the results by that process in the assay office. So far, this year, the results of the process in the mill exceed the assay office results by 1.27 per cent.

The mill extraction at Yedras, as given in Table VI, is not as high as at most other mills using the process. This is due to the fact that the roasting in the reverberatories, owing to the large loss of silver, which may then take place, if it is too long continued, or at too high a temperature, must be conducted with reference to this loss as well as to the subsequent extraction by lixiviation. The roasting might be so conducted as to yield 92 or 93 per cent. of the value of the roasted ore by lixiviation, but such a roasting would cause a greater loss of silver by volatilization. Also, if more salt were used the per cent. of extraction from the roasted ore would be higher. But salt costs at Yedras about twelve times as much as at Park City, Utah. With seven per cent. salt and the roasting as at present conducted, the loss by volatilization is 6 to 8 per cent., and the extraction from the roasted ore 87 per cent. This is better economically than to use a larger per cent. of salt or roast longer, even with 92 per cent. extraction from the roasted ore as a result.

NOTE.—The statistics for 1892 are furnished by H. H. Hughes, Superintendent of the Anglo-Mexican Mining Company at Yedras.

TABLE VII.

DIFFERENCE BETWEEN ASSAY OFFICE AND MILL RESULTS
FOR FIVE YEARS.

Year.	Russell Process in Mill over Old Process in Assay Office.	Russell Process in Mill over Old Process in Mill. (See Table A.)	Russell Process in Mill over (+) or below (-) Russell Process in Assay Office.
	Per Cent.	Per Cent.	Per Cent.
1888	11.13		+0.02
1889	8.47		-0.29
1890	9.17		+0.54
1891	11.62	11.49	-4.75
1892	17.07	+ 4.97	+1.27
Average	11.49	16.46	-0.64

As shown in above Table VII, the Russell Process during the past five years has extracted in the mill 16.46 per cent. of the value of the ore more than could be extracted by the Old Process in the mill. Also, the extraction by the Russell Process in the mill averaged only 64-100 of one per cent. less than the highest extraction obtainable by that Process in the assay office.

TABLE VIII.

VALUES OF PRODUCTS AND DISTRIBUTION OF VALUES IN PRODUCTS.

Year.	Per Cent. Silver in each Product.				Distribution of Silver in the Products.		
	Wash Water and Weak Solution Sulphides.	Sulphides from "Ordinary Solution."	Sulphides from "Extra Solution."	Average Value of Total Product.	Per Cent. of Total Pro- duct in Wash Water and Weak Solu- tion Sul- phides.	Per Cent. of Total Pro- duct in Sul- phides from Ordinary Solutions.	Per Cent. of Total Pro- duct in Sul- phides from Extra Solution.
	Per Cent. Silver.	Per Cent. Silver.	Per Cent. Silver.	Per Cent. Silver.	Per Cent.	Per Cent.	Per Cent.
1890	46.47	69.10	24.79	60.2	10.0	75.0	15.0

TREATMENT OF OLD TAILINGS

BY THE RUSSELL PROCESS.

All the tailings which had been produced at the Vedras mill by the old leaching process, before the introduction of the Russell Process in 1887, have now been re-treated by the latter. The manipulations of the solutions for tailings is practically the same as in the treatment of ore.

The tailings are brought from the old dumps, where they had been thrown out in former years, and are charged directly to the leaching vats without any drying, roasting or other preliminary treatment. Like the charges of ore, they are leached first with water in order to remove the small per cent. of soluble salts which is present, this washing requiring about four hours. A small amount of ordinary hypo-sulphite solution is then applied, not because this solution extracts anything, as it extracts absolutely nothing. But, as the volume of the "extra solution" is only enough to saturate the charge, and it would become diluted to some extent with the wash water if it followed that, the small volume of ordinary solution is interposed between them.

As in treating ore, the "extra solution" amounts to 13 cubic feet per ton. It is followed by more of the ordinary hyposulphite solution to extract any silver which has been made soluble by the "extra solution" but which has not passed out of the charge with that solution, but remains mechanically held in the pulp.

The total amount of tailings from the old leaching process at Vedras which have been re-treated by the Russell Process is about 30,000 tons.

Table IX gives the assay office and mill results on the tailings re-treated in 1889.

TABLE IX.

TREATMENT OF OLD TAILINGS BY RUSSELL PROCESS—1889.

MONTH.	Value Per Ton.	Per Cent. by Old Process in Assay Office.	Per Cent. by Russell Process in Assay Office.	Per Cent. by Old Process in Mill.	Actual "Clean Up" by Russell Process in Mill.
	Ounces.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
January....	18.49	33.60	62.30	The old process extracted nothing in mill.	70.46
February...	18.40	35.49	59.30		63.43
March.....	17.45	28.60	56.39		56.13
April.....	16.39	30.63	58.27		66.93
May.....	17.92	36.72	61.22		74.07
June.....	16.14	31.11	56.63		53.50
July.....	16.00	33.75	56.75		55.90
August....	14.68	31.00	56.68		64.87
September..	18.26	37.03	58.60		52.51
Averages ..	17.23	32.17	57.20	0.0	60.14

No tailings were treated in October, November or December of 1889, nor in June, July, August, September or December, 1890.

Table X gives the results on tailings for 1890.

TABLE X.

TREATMENT OF OLD TAILINGS BY THE RUSSELL PROCESS—1890.

MONTH.	Value Per Ton.	Per Cent. by Old Process in Assay Office.	Per Cent. by Russell Process in Assay Office.	Per Cent. by Old Process in Mill.	Actual "Clean Up" by Russell Process in Mill.
	Ounces.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
January....	13.02	24.35	39.56	The old process extracted nothing in mill.	34.09
February...	15.24	36.62	50.20		47.95
March.....	15.48	36.12	53.88		55.00
April.....	13.03	32.00	53.80		45.28
May.....	10.93	30.38	45.29		59.73
October....	10.41	26.50	35.50		34.28
November..	11.50	31.83	43.57		43.91
Averages ..	13.46	34.48	49.26		0.0

In both the foregoing tables it will be noticed that the old leaching process in the mill fails to extract anything from the tailings which had been previously produced by it, although in the assay office the extraction from these tailings by that process is 32.0 to 34.0 per cent.

Tables XI and XII give the chemicals consumed in leaching for the months corresponding to those of Tables IX and X.

TABLE XI.

TREATMENT OF OLD TAILINGS BY THE RUSSELL PROCESS.
CHEMICALS USED PER TON—1889.

Month.	Hyposulphite.	Blue Stone.	Caustic Soda.	Sulphur.	Total Chemicals. Per Ton.
	lbs.	lbs.	lbs.	lbs.	lbs.
January.....	1.07	5.70	4.82	3.21	14.80
February.....	1.33	5.71	4.00	2.66	13.70
March.....	1.50	5.82	*14.21	*7.10	*28.63
April.....	2.46	6.00	4.31	2.86	15.63
May.....	2.86	6.10	3.89	2.59	15.44
June.....	1.65	5.31	3.21	2.14	12.31
July.....	1.94	5.12	2.68	1.78	11.52
August.....	1.13	5.03	2.84	1.89	10.89
September.....	1.31	4.62	3.50	2.33	11.76
Averages.....	1.62	5.11	3.13	2.69	12.55

* Caustic lime, as during March "calcium sulphide" was used as a precipitant for silver sulphide. As a result the cost of precipitating was increased about 25 per cent. instead of sodium for that month.

TABLE XII.

TREATMENT OF OLD TAILINGS BY THE RUSSELL PROCESS.
CHEMICALS USED PER TON—1890.

MONTH.	Hypo-Sulphite.	Bluestone.	Caustic Soda.	Sulphur.	Total Chemicals Per Ton.
	lbs.	lbs.	lbs.	lbs.	lbs.
January	0.85	3.80	2.21	1.47	8.33
February.....	1.08	3.84	2.45	1.69	9.06
March.....	2.85	4.27	1.74	1.20	10.06
April.....	1.89	4.26	2.48	1.72	10.35
May.....	0.77	3.69	2.54	1.76	8.76
October.....	0.02	4.17	2.29	1.57	8.05
November.....	0.04	4.43	3.67	2.53	10.67
Averages.....	1.07	4.06	2.48	1.71	9.33

Tables XIII and XIV give a summary of statistics on the treatment of the old tailings at Yedras for three years. Naturally the richest of these old tailings were treated first, which accounts for their decreasing value.

TABLE XIII.

TREATMENT OF OLD TAILINGS BY THE RUSSELL PROCESS AT YEDRAS.

SUMMARY.

Year.	Value per Ton.	Per Cent. by Old Process in Assay Office.	Per Cent. by Russell Process in Assay Office	Per Cent. by Old Process in Mill.	Apparent per Cent. by Russell Process in Mill.	Apparent by Russell Process in Mill below that Process in Assay Office.	Actual Extraction by Russell Process in Mill.
	Ozs.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1888	19.49	37.40	62.70	Old Process extracts nothing in Mill.	60.14	-2.53	62.74
1889	17.23	32.17	57.20		55.95	-1.25	60.14
1890	13.46	38.48	49.26		48.37	-0.89	46.84
Averages	16.73	36.02	56.39	00.00	54.82	-1.57	56.57

In the above table "apparent" extraction in mill is obtained by comparing the value per ton of the final tailings with the old tailings as

charged to the leaching vats (taking into account any soluble salts also).

“Actual extraction” in mill is obtained by comparing the “clean up” in silver with the silver actually charged to leaching vats.

The “actual” extraction averages $1\frac{3}{4}$ per cent. above the “apparent” for the three years.

TABLE XIV.

TREATMENT OF OLD TAILINGS BY THE RUSSELL PROCESS AT YEDRAS.

SUMMARY—CONTINUED.

CHEMICALS USED PER TON, ETC.

Year.	Hypo-sulphite.	Blue Stone.	Caustic Soda.	Sulphur.	Total Chemicals per Ton.	Cost of Chemicals per Ton.	Ounces Silver Extracted per Ton.
	lbs.	lbs.	lbs.	lbs.	lbs.	Dollars.	Ozs.
1888	2.08	6.32	4.54	3.30	16.24	1.45	12.23
1889	1.62	5.11	3.13	2.69	12.55	1.12	9.75
1890	1.07	4.06	2.48	1.71	9.33	0.84	6.30
Averages	1.59	5.10	3.38	2.57	12.64	1.13	9.43

The value of the product from the treatment of old tailings at Yedras, by the Russell Process, averages about 25 per cent. in silver, or approximately 7,000 ounces per ton.

SUMMARY.

Tables IV and XIV give the chemicals on both ore and tailings for the years 1888, 1889 and 1890, as follows:

YEAR.	Total Chemicals Per Ton for Ore.	Total Chemicals Per Ton for Tailings.
	lbs.	lbs.
1888	17.18	16.24
1889	12.26	12.55
1890	9.14	9.33

The above Table illustrates a fact, which, I believe, has been observed wherever the Russell Process has been used, viz.: That the amount of chemicals consumed per ton is practically independent of the richness of the ore. For, in the above case, the amount of silver extracted from the ore per ton is four to six times the amount extracted from the tailings and yet the weight of chemicals used per ton is almost exactly the same.

The average amount and cost of chemicals per ton used in re-treating the old tailings at Yedras by the Russell Process, during the above three years, has been as follows:

Hyposulphite	1.59 lbs. at	8.0 cents.....	12.72 cents.
Blue Stone	5.10 " "	10.0 "	51.00 cents.
Caustic Soda	3.38 " "	9.1 "	30.76 cents.
Sulphur	2.57 " "	7.1 "	18.24 cents.
	<u>12.64</u>		<u>\$1.127²/₁₀₀</u>

In the United States, for instance, at Park City, Aspen or Butte, the cost of these chemicals would be about 65 cents, instead of \$1.13, per ton of tailings.

The average actual extraction in silver from these old tailings during these three years has been 56.57 per cent., or 9.46 ozs. per ton. The average price of silver in the United States for this period was 97 cents per oz., making the gross extraction of silver from the tailings equal to \$9.18 per ton.

The following table gives the average expenses and profits at Yedras arising from the treatment of these tailings by the Russell

Process at the rate of 50 tons per day (the usual rate being 30 to 50 tons):

Chemicals.....per ton.....	\$1.13
Loading.....per ton.....	0.25
Unloading.....per ton.....	0.13
Labor in leaching.....per ton.....	0.29
Fuel and power.....per ton.....	0.13
Product and sundry expense per ton.....	0.50
Total expenses per ton.....	<u>\$2.43</u>

RECAPITULATION.

Extraction per ton (9.43 ozs. at 97 cts.).....	\$9.18
Expenses per ton.....	<u>2.43</u>
Net profit per ton.....	\$6.75

The statistics which have just been given refer to the treatment of Yedras tailings only. We now come to a comparison of the Russell Process and the old leaching process in the treatment of Yedras ore.

During the past five years the comparative efficiency of these two processes at the Yedras mill has been tested four times. The duration of each of these tests was from one to three months.

Two of these were made by my predecessor in charge of the mill, Mr. F. M. Johnson, and two by myself.

Two methods were pursued in making these comparative runs. One was to divide the roasted ore equally between the two processes, running one-half the ore vats and precipitating tanks on the old process and the other half by the Russell Process, the products being kept entirely separate and the tailings from each process being thrown out. By this method, however, there is a loss of seven to ten ounces per ton on all the ore treated by the old leaching process; as that amount, which might be extracted by the Russell Process, if it were used on those charges after the old process, remains in the tailings and is lost.

In the other method of making the comparison between the two processes, all the charges are treated first by the old process, that is by the simple hypo-sulphite solution, until no more silver can be extracted by that process, the sulphides being precipitated by themselves and kept separate. Then these same charges of ore are treated by the Russell Process, that is by a cuprous hypo-sulphite, or "extra" solution. The precipitates from this solution are likewise kept separate. In this way a comparison between the two processes is made without any loss, each charge of ore having the benefit of being treated by both processes before it is thrown out.

In fact this is the way all the ore is treated at Yedras, whether a comparison is being made or not, all charges being first treated by the old process and then by the Russell Process.

The first of the two comparative runs made by myself between the two processes was in September, 1890, the test being continued during the whole of the month.

I extract from my report to the Anglo-Mexican Company, made at the time on this test run :

“Our intention was to give the old process every possible show. Great care was taken to keep the precipitates separate, both at the beginning and end of the month. The tons of ore in question were totally leached out. During the month no experiments, or extra ‘clean up,’ was carried out. In making the test we allowed the old process to take out all it could take, *i. e.*, we ran the vats (by the old process) as long as sodium sulphide would show the least trace of silver in the solution. When the old process would not take any more silver out, the ‘extra solution’ of the Russell Process was applied, and, as in the case of the old process, was run as long as sodium sulphide showed any trace of silver coming out.”

The actual “clean ups” from the two processes were as follows:

Extracted by the old leaching process.....	26,361.42 ozs.
Additional extracted by the Russell Process,	5,088.76 ozs.
Total.....	31,450.18 ozs.

Per cent. of total product extracted by old process.....	83.8
Per cent. of total product extracted by Russell process.....	16.2

That is, after the old process had done its utmost work, extracting 26,361.42 ozs., the Russell Process was used on the same charges of ore and extracted 5,088.76 ounces more.

The total chemicals used per ton for both processes was:

Hyposulphite of Soda.....	0.0 lbs. at 8.1 cents....	0.00
Blue Stone.....	3.0 lbs. at 10.0 cents....	33.00
Caustic Soda.....	3.58 lbs. at 9.1 cents....	28.60
Sulphur.....	2.48 lbs. at 9.3 cents....	17.40
Total.....	9.06	\$0.79.00

The total additional cost of the Russell Process, or in other words, the extra expense of producing this 5,088.76 ozs. over the cost of the old process was as follows:

Chemicals.....	\$632.50
Fuel.....	21.21
Extra help, etc.....	155.60
Total....	\$809.31

At the then price of silver the 5,088.76 ozs. equalled \$5,852.07. Deducting the above expenses there is left \$5,042.76 as the net profit per month due to the use of the Russell Process.

The second test made by myself on the comparative efficiency of the two processes was carried out during the month of November, 1890.

In this run the total chemicals used per ton for both processes were:

Hypo-sulphite	0.35 lbs.
Blue Stone	6.40 lbs.
Caustic Soda.....	2.84 lbs.
Sulphur.....	1.70 lbs.
Total.....	11.29 lbs.

The total cost of these chemicals per ton was 95 cents.

Of the total ounces extracted the old process took out 80.29 per cent. and the Russell Process the remaining 19.71 per cent. The additional ounces silver extracted by the Russell Process over the old process were 7,653.7, or (with silver at \$1.02.5 per oz.), \$7,845.04, making a net profit due to the use of the Russell Process of about \$7,000 per month.

Of the two comparative runs made by my predecessor in charge of the mill, Mr. F. M. Johnson, the first was made during the first three months of the use of the Russell Process. The following table from June to December, 1887, shows the mill extraction by the old leaching process for seven months and the results by the Russell Process for two months.

TABLE XV.

MILL RESULTS FOR SEVEN MONTHS, 1887.

Month.	Extraction in Mill by Old Process.	Extraction in Mill by Russell Process.	
	Per Cent.	Per Cent.	
June	71.1	Process not in use until November.	
July	66.0		
August	66.0		
September	73.1		
October	63.1		
November	63.7		81.2
December	67.3		82.2

The following is from the printed report of Mr. F. M. Johnson on the above mentioned comparative run between the two processes. The data on the "old process" dates from June 1, 1887, up to and

including January 31, 1888. The data on the "Russell Process" dates from November 1 (when it was introduced), 1887, up to January 31, 1888.

TABLE A.

OLD LEACHING PROCESS.—ASSAY OFFICE AND MILL RESULTS.

Number of Months Run.	Value per Ton.	Extraction in the Assay Office.	Extraction in Mill.	Extraction in Mill below Assay Office.	Total Leaching Time.
No.	Ozs.	Per Cent.	Per Cent.	Per Cent.	Hours.
8	60.67	72.09	67.12	-4.97	92

TABLE B.

RUSSELL PROCESS.—ASSAY OFFICE AND MILL RESULTS.

Number of Months Run.	Value per Ton.	Extracted by Old Process in Assay Office.	Extracted by Russell Process in Assay Office.	Extracted by Russell Process in Mill.	Difference between Old Process in Assay Office and Russell Process in Mill.	Difference between Russell Process in Assay Office and Mill.	Total Leaching Time.
	Ozs.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Hours.
3	55.3	69.94	83.62	82.44	12.5	- 1.18	76

TABLE C.

OLD LEACHING PROCESS—CHEMICALS PER TON.

Lime.	Sulphur.	Total Chemicals Per Ton.	Total Cost Per Ton.
lbs.	lbs.	lbs.	Dollars
9.7	4.7	14.4	0.52

TABLE D.

RUSSELL PROCESS—CHEMICALS PER TON.

Hypo-Sulphite.	Bluestone.	Caustic Soda.	Sulphur.	Total Chemicals Per Ton.	Total Cost Per Ton.
lbs.	lbs.	lbs.	lbs.	lbs.	\$
1.4	9.6	5.5	3.6	20.1	2.20

NOTE 1.—By referring to the above tables (A and B) it will be seen that the old process in the assay office extracts 4.97 more than the old process in mill, and 12.05 per cent. less than the Russell Process in the mill, which shows a net gain in extraction in favor of the Russell Process of 17.47 per cent.

NOTE 2.—That the time for treatment is shortened by the Russell Process.

NOTE 3.—That the cost for chemicals in the Russell Process is \$1.68 more than in the old process, (C and D)

NOTE 4.—The net gain in extraction of 17.47 per cent. (A and B) on 60 ounce ore would be 10.48 ounces, or \$10.06 per ton (with silver at 96 cents per oz.) From this take \$1.68 (the extra cost for chemicals in the Russell Process) and there will be left a profit of \$8.38 per ton. If 12,000 tons be treated in a year the net gain in profits by using the Russell Process would be \$100,560.00 per year.

The above is the report of Mr. Johnson, dated Feb. 7, 1888. Being the first three months run the amount of chemicals is much greater than afterward, and also the cost per ton, as shown by the following table:

AMOUNT AND COST OF CHEMICALS FOR DIFFERENT PERIODS
BY RUSSELL PROCESS.

Period.	Weight of Chemicals per Ton of Ore.	Cost of Chemicals per Ton of Ore.
	lbs.	Dollars.
First 3 months run as per above report.	20.10	2.20
1888	17.18	1.54
1889	12.26	1.10
1890	9.14	0.85
1891	14.48	1.36
1892	13.15	1.38

The following is the report of Mr. Johnson on the second comparative run made by him in August, 1889, the report being dated September 7, 1889:

“THE EFFICIENCY OF THE ‘EXTRA SOLUTION’ IN RUSSELL’S IMPROVED PROCESS OF LIXIVIATION AT THE YEDRAS MILL.—REMARKS.

“To determine the actual efficiency of the extra solution of the Russell Process, on Yedras ores, we precipitated the silver-bearing solution of simple hypo-sulphite of soda coming from the ore in a separate set of vats. The silver extracted by the extra solution of the Russell Process was also precipitated in vats by itself. We aimed to leach all the silver out of the ore that the simple hypo-sulphite of soda solution was capable of extracting, and then the extra solution was added to the same ore to further the extraction.

TABLE NO. 1.

	Ozs. Extracted as Sulphides Without Use of Russell Process.	Ounces Extracted as Sulphides by the Russell Process.
Amount extracted during base metal leaching (<i>i. e.</i> , first wash water)....	3,576.26	
Amount extracted by simple hypo- sulphite solution.....	23,678.66	
Amount extracted by extra solution after the simple hypo-sulphite had done its utmost work.....		10,115.20
Totals.....	27,254.92	10,115.20

Amount extracted by both methods in sulphides.....37,370.12 ounces.
Per cent. of total extraction by simple hypo-sulphite
solution and wash water (old process) 72.93 per cent.
Additional extraction by extra solution (Russell Process) 27.07 per cent.

TABLE NO. 2.

COST OF ADDITIONAL CHEMICALS USED IN RUSSELL PROCESS.

Hyposulphite of Soda.....	1687 lbs. @ 7.7 =	\$ 129.90
Blue Stone.....	8650 lbs. @ 8.5 =	735.25
Caustic Soda.....	2292 lbs. @ 6.2 =	142.10
Sulphur.....	1528 lbs. @ 5.4 =	82.51
Total cost of Chemicals for Russell Process.....		\$1,089.76

REMARKS ON TABLES I AND 2.

“The value of the silver which was further extracted by the Russell Process is \$9,407.14. Subtracting the cost of the chemicals, \$1,089.76, from this leaves \$8,317.38, which is the net profit due to the use of the “extra solution” of the Russell Process over and above the simple hypo-sulphite solution (or old process) expressed in dollars, for the month of August.

“The extraction by the hypo-sulphite solution (old process) is probably a little greater than it would have been if the stock solution (of that process) had not been kept in thorough condition due to the use of the bluestone (of the Russell Process) which was used in the extra solution.”

The net savings at Yedras due to the use of the Russell Process over the old leaching process may be summed up as follows. (All the old tailings have already been treated.)

	Net Saving per Year.
On tailings at rate of 1,500 tons per month	\$121,500.00
On ore as per 1st comparative mill run	100,560.00
On ore as per 2d comparative mill run.....	99,808.56
On ore as per 3d comparative mill run.....	60,513.12
On ore as per 4th comparative mill run.....	84,000.00

The amount of ore treated at Yedras varies from 1000 to 1200 tons per month.

Omitting the profits arising from the treatment of the old tailings, the net profits per year, due to the use of the Russell Process, over the old leaching process on *ore*, at Yedras, have averaged \$86,000.00 per year, or \$6.00 to \$7.00 per ton. The difference in extraction of silver in the mill for the five years has averaged 16.5 per cent. of the value of the ore in favor of the Russell Process and in the treatment of old tailings 56.6 per cent. of their value, over the extraction by the old leaching process.

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