# EXPERIMENTAL WORK IN THE RECOVERY OF GOLD FROM A MASSIVE SULPHIDE ORE

by

Warren C. Cornell

---

A Thesis

submitted to the faculty of the

Department of Mining and Metallurgy

in partial fulfillment of

the requirements for the degree of

Master of Science

in the Graduate College

University of Arizona

1937

---

Approved: T. S. Lovering, 5-17-37

Major Professor Date.

## ACKNOWLEDGMENT

The writer wishes to express his sincere gratitude to Dr. T. G. Chapman for his guidance during the course of the experimental work and aid in the preparation of this manuscript.

CONTENTS

--


| Chapter | | Page |
|---|---|---|
| I | Introduction . . . . . | 1 |
| II | Apparatus and Materials . . . . . | 6 |
| III | Experimental Work | |
| | Consumption of Alkali and Cyanide. . . | 9 |
| | Solubility of Gold and Silver in Cyanide . . . . . | 10 |
| | Amalgamation . . . . . | 12 |
| | Flotation. . . . . | 14 |
| IV | Conclusions. . . . . | 27 |

# EXPERIMENTAL WORK IN THE RECOVERY OF GOLD FROM A MASSIVE SULPHIDE ORE

by

Warren C. Cornell

---

## CHAPTER I. INTRODUCTION

A massive sulphide ore is one usually considered to contain, within reasonable variations, over 50 per cent of metallic sulphides with the balance represented by gangue minerals.

Among types of massive sulphide ores may be mentioned the Rio Tinto copper deposits, the Sudbury copper-nickel ores, the mixed sulphide ores of lead, zinc, copper and iron, and some relatively small deposits of massive pyrite containing appreciable gold values and minor amounts of chalcopyrite.

A brief review of some of the important methods of treating massive sulphide ores, currently and in the past, was believed to be of interest in this paper.

At Rio Tinto[1] massive sulphide ore was and is treated by a process known as Heap Leaching for the recovery of the copper content. The ore is essentially a massive pyrite with impregnated schist averaging 2.5 per cent of copper and 45 per cent of sulphur. The process consists briefly, of crushing to 3 inches, piling the ore in large heaps with a flat top surface, and treatment by successive oxidizing, downward leaching and draining periods for as many years as necessary to obtain the desired recovery. The copper is precipitated from solution in launders with iron, and the leached residue is shipped to sulphuric acid plants.

Pyritic Smelting[2] is a process which was used at Ducktown, Tenn. in which the oxidation of pyrites and the formation of the slag furnished most of the heat necessary to carry on the operation for producing a matte. The three essential requirements were pyrite, free or uncombined silica, and oxygen.

For many years the massive sulphide ores of Sudbury, Ontario[3] were heap roasted after which the copper,

---

1 - Hofman and Hayward, Metallurgy of Copper, 2nd Ed., p. 306, McGraw-Hill Book Co.
2 - Hofman and Hayward, Metallurgy of Copper, 2nd Ed., p. 142, McGraw-Hill Book Co.
3 - MacAskill and Coleman, Engineering and Mining Journal, Nov. 10, 1930, p. 473

nickel, gold, and silver values were recovered by blast furnace smelting followed by subsequent converting and refining operations. Similar methods are used for these ores to-day except that shelf roasting furnaces and reverberatory furnaces have been substituted for heap roasting and blast furnace, respectively.

The mixed lead,[4] zinc, copper, iron sulphide problem was usually associated more or less with semi massive sulphide ores and has been largely solved by selective flotation methods whereby separate concentrates of lead, zinc, and iron are feasible.

The treatment of massive sulphide gold ores by flotation has been a comparatively recent advent in the general practice of milling.

Noranda Mines Ltd. at Noranda, Quebec was probably one of the first companies to install flotation on a commercial scale for the recovery of gold and copper from massive sulphide ores beginning in 1928.[5] The ores were, as mentioned, massive sulphides carrying copper as chalcopyrite and gold, both free and combined with the base metal sulphides. The principal feature of the operation was the aeration of the pulp from the classifier overflow before flotation treatment by four stages of roughing.

---

4 - Gaudin-Flotation, 1932, p. 196, McGraw-Hill Book Co.
5 - MacLachlin, C.G., Transactions of the Canadian Institute of Mining and Metallurgy and of the Mining Society of Nova Scotia, Vol. 33, 1930

In the flotation circuit, soda ash and cyanide were used as iron and zinc depressants.

At Flin Flon[6] massive sulphide ore was ground to 85 per cent minus 325-mesh and treated in three selective flotation circuits. The first circuit removed talc by one roughing stage with a single cleaning of the talc concentrate. The second removed copper by one roughing stage with a single cleaning of rougher concentrate, while the third removed zinc with a single cleaning of concentrate. The circuits were all connected in series in the order given and the tailing of the last circuit was cyanided to recover residual gold and silver values. The removal of talc was accomplished using pine oil and zinc sulphate. The copper was floated with aerofloat, zanthate, and sodium chloride; while the zinc was removed with copper sulphate, cresylic acid, lime, and zanthate.

The ore treated at the McIntyre Porcupine Mines Ltd.[7] is a quartz sulphide mixture with the gold associated with both pyrite and quartz, but predominating in the former. This ore is not a massive sulphide ore but since the pyrite and gold are first recovered by flotation, the concentrate from this operation is similar in character to a finely ground massive sulphide ore. After removal of the pyrite and gold by flotation, the concentrate is ground

---

6 - Lowe, S.P., Transactions of the Canadian Institute of Mining and Metallurgy and of the Mining Society of Nova Scotia, Vol. 33, 1930, p. 222

7 - Denny, J.J.-McIntyre Metallurgy, Engineering and Mining Journal, Vol. 134, 1933, p. 472

to 325-mesh and treated by cyanidation. Although the resulting recovery was lower than former recoveries by direct cyanidation, certain advantages in operating costs yielded a higher net return than direct cyanidation.

Some small deposits of massive ores exist which contain gold associated with massive pyrite with minor quantities of chalcopyrite. For one reason or another, small deposits of this character have not usually been amenable commercially to any of the methods which have been outlined herein, and the purpose of the experimental work described in this paper is to experiment with possible methods for the treatment of such an ore.

## CHAPTER II - APPARATUS AND MATERIALS

The sample of ore for the tests described herein was a massive sulphide pyritic material containing gold and minor amounts of chalcopyrite. Analyses furnished by the Department of Mining and Metallurgy are as follows:

| | Per cent |
|---|---|
| Copper | 0.14 |
| Lead | 0.50 |
| Iron | 26.00 |
| Insoluble | 48.10 |
| Gold, ounces per ton | 0.68 |
| Silver, ounces per ton | 3.83 |

The pyrite content, computed from the analyses presented, amounted to slightly more than 50 per cent.

A sample weighing 18 pounds ground to 10-mesh size was furnished for the experimental work. This lot was dry ground to 70 per cent minus 200-mesh in a 24 inch Hardinge ball mill. A screen-assay test, which shows the distribution of the gold and silver according to screen sizes, is presented in Table 1.

Table 1--Distribution of gold and silver by original sample by screen sizes.

| Screen size, mesh | Weight, grams | Tons in 100 | Assays, ounces per ton | | Weight of metals, ounces | | Per cent of total metal | |
|---|---|---|---|---|---|---|---|---|
| | | | Gold | Silver | Gold | Silver | Gold | Silver |
| Heads | 500.0 | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.0 | 100.0 |
| -65 +100 | 11.5 | 2.30 | 1.09 | 3.66 | 2.51 | 8.41 | 3.7 | 2.2 |
| -100 +150 | 70.0 | 14.00 | 0.54 | 1.26 | 7.56 | 17.64 | 11.1 | 4.6 |
| -150 +200 | 68.5 | 13.70 | 0.78 | 2.12 | 10.68 | 29.00 | 15.7 | 7.6 |
| -200 Sands | 175.0 | 35.00 | 0.99 | 4.20 | 34.65 | 147.00 | 51.0 | 38.4 |
| -200 Slimes | 175.0 | 35.00 | 0.36 | 5.17 | 12.60 | 180.95 | 18.5 | 47.2 |

Cyanidation and amalgamation tests were made in bottles of 1 and 2 liters capacity revolved on horizontal rolls. Flotation tests were conducted in 500 and 2000 gram capacity Denver flotation machines. Gravity separations were made on a laboratory size Wilfley table. Regrinding of concentrates was done in an 8-inch laboratory Abbey Mill using ½inch cast iron balls.

# CHAPTER III - EXPERIMENTAL WORK

## Consumption of Alkali and Cyanide

A sample of 50 grams ground to 70 per cent minus 200-mesh was agitated for 20 minutes with 100 c.c. of 0.1 normal sodium hydroxide solution. The results indicated a consumption of 10.9 pounds of sodium hydroxide or 7.74 pounds of lime per ton of material tested.

A test for cyanide consumption was made by agitating duplicate 50-gram samples of ore in a solution containing 75 c.c. of 0.1 normal sodium hydroxide and 75 c.c. of 0.1 per cent sodium cyanide for 20 minutes. The results indicated a consumption of 13.8 pounds of cyanide per ton of ore.

A test was made to determine the cyanide consumption and the protective alkalinity using longer periods of agitation and replacing sodium hydroxide with lime. Two samples of 100 grams each were agitated in cyanide solution of 0.2 per cent strength for 3 hours. Lime was added at the rate of 7.7 pounds per ton. The results indicated a cyanide consumption of 13.5 pounds per ton of ore and 0.56 pounds of lime per ton of solution as protective alkali.

## Solubility of Gold and Silver in Cyanide

Duplicate samples of 100 grams each, ground to 70 per cent minus 200-mesh, were agitated for 3 hours with cyanide and indicated recoveries, cyanide consumption, and protective alkalinity determined. The results marked Sample A are given in Table 2.

Duplicate tests for solubility of gold and silver for a 48-hour agitating period were made and the results are given in Table 2 under Sample B.

Referring to Table 2, the results of a 3-hour agitating period indicated extractions of 52.8 and 31.4 per cents of the total gold and silver, respectively, with a cyanide consumption of 13.5 pounds per ton of material tested.

The indicated extractions for a 48-hour agitating period amounted to 97.0 and 41.9 per cents of the total gold and silver, respectively, with cyanide consumption of 18.0 pounds per ton of material tested.

Table 2--Details of small scale cyanidation tests

| Sample | Time, hours | Total solution, c.c. | Assays, oz. per ton sol. | | Recoveries, per cents | | Cyanide consumption, pounds per ton | CaO in solution, pounds per ton |
|---|---|---|---|---|---|---|---|---|
| | | | Gold | Silver | Gold | Silver | | |
| A | 3 | 200.0 | 0.18 | 0.60 | 52.8 | 31.4 | 13.5 | 0.56 |
| B | 48 | 220.0 | 0.30 | 0.73 | 97.0 | 41.9 | 18.0 | 0.40 |

## AMALGAMATION

Three amalgamation tests were made of the material ground to 70 per cent minus 200-mesh. Tests A and C were made with mercury for 3 and 24-hour agitating periods, respectively, and Test B with sodium amalgam and a 24-hour contact period. The results are presented in Table 3 based on heads and tailings assays.

Referring to Table 3, amalgamation for the 3-hour Test A with mercury showed recoveries of 27.0 and 8.0 per cents of the total gold and silver, respectively.

A contact period of 24-hours (Test C) indicated recoveries of 32.2 and 4.4 per cents of the total gold and silver, respectively.

A contact period of 24 hours (Test B) with sodium amalgam showed recoveries of 26.2 and 4.4 per cents of the total gold and silver, respectively.

Tests with mercury did not show any appreciable flouring of the mercury but the test with sodium amalgam did show considerable flouring.

Table 3--Amalgamation tests

| Test, No. | Weight of ore, grams | Time, hours | Mercury added, grams | Water added, c.c. | Assays, ounces per ton | | | | Indicated recoveries, per cents | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Heads | | Tailings | | | |
| | | | | | Gold | Silver | Gold | Silver | Gold | Silver |
| A | 100.0 | 3 | 10 | 50 | 0.68 | 3.83 | 49.6 | 3.52 | 27.0 | 8.0 |
| B | 100.0 | 24 | 10 | 50 | 0.68 | 3.83 | 50.2 | 3.66 | 26.2 | 4.4 |
| C | 100.0 | 24 | 10 | 50 | 0.68 | 3.83 | 46.2 | 3.66 | 32.2 | 4.4 |

## Flotation

### Test 1

A sample of 500 grams of ore, ground 70 per cent minus 200-mesh, was treated in a Denver 500-gram capacity flotation machine with amyl zanthate and pine oil added in stages at the total rates of 0.20 and 0.10 pounds per ton of ore, respectively. The operation was a bulk flotation operation with the idea of recovering all the sulphides, and resulted in the production of three froth products numbered 1 to 3 inclusive. The flotation tailing was panned to recover any coarse free gold. The p H value of the water just before the froth was removed was 6.2. The results of this test are presented in Table 4. A summary of the results of Table 4 are given in Table 5.

Referring to Tables 4 and 5, concentrates 1, 2, and 3 contained 83.3, 9.7, and 0.3 per cents of the total gold, respectively. These three products combined into one concentrate (Table 5) contained 93.3 per cent of the total gold and assayed 1.05 ounces of gold and 5.53 ounces of silver per ton of concentrate. The concentration ratio was 100 to 60.4. The pan concentrate contained 5.7 and 6.5

Table 4--Detailed results of Test 1.

| | Weights, grams | Tons in 100 | Assays, ounces per ton | | Tons X assays, ounces | | Per cents of total | |
|---|---|---|---|---|---|---|---|---|
| | | | Gold | Silver | Gold | Silver | Gold | Silver |
| Heads | 500.0 | 100.0 | 0.68 | 3.83 | 68.00 | 383.0 | 100.0 | 100.0 |
| Conc. No. 1 | 236.0 | 47.2 | 1.20 | 5.56 | 56.60 | 262.4 | 83.3 | 68.5 |
| Conc. No. 2 | 42.3 | 8.4 | 0.79 | 6.90 | 6.63 | 57.9 | 9.7 | 15.1 |
| Conc. No. 3 | 23.7 | 4.7 | 0.05 | 2.87 | 0.23 | 13.5 | 0.3 | 3.5 |
| Pan Concentrate | 30.0 | 6.0 | 0.64 | 4.10 | 3.87 | 25.0 | 5.7 | 6.5 |
| Tailing | 168.0 | 33.6 | 0.02 | 0.72 | 0.67 | 24.2 | 1.0 | 6.3 |

Table 5--Summary of Table 4 results.

| | Weights, grams | Tons in 100 | Assays, ounces per ton | | Tons X assays, ounces | | Per cents of total | |
|---|---|---|---|---|---|---|---|---|
| | | | Gold | Silver | Gold | Silver | Gold | Silver |
| Heads | 500 | 100.0 | 0.68 | 3.83 | 68.00 | 383.0 | 100.0 | 100.0 |
| Combined Concts. | 302 | 60.4 | 1.05 | 5.53 | 63.46 | 333.8 | 93.3 | 87.1 |
| Pan Concentrate | 30 | 6.0 | 0.64 | 4.10 | 3.87 | 25.0 | 5.7 | 6.5 |
| Tailing | 168 | 33.6 | 0.02 | 0.72 | 0.67 | 24.2 | 1.0 | 6.3 |

per cents of the gold and silver, respectively.

Test 2

A sample of 500 grams of ore, ground to 70 per cent minus 200-mesh, was treated in a Denver 2000-gram capacity flotation machine with amyl zanthate and pine oil at the rates of 0,35 and 0.20 pounds per ton of ore, respectively. This was a bulk flotation operation with the purpose of recovering the sulphides. This operation gave a rougher concentrate and tailing. The rougher concentrate was refloated with lime added at the rate of 10 pounds per ton of original ore, which gave a p H value of 10.6 and produced concentrate 1 and a middling. The middling was retreated with zanthate added at the rate of 0.02 pounds per ton of ore and produced concentrate 2 and middling 1. Concentrate 1 was retreated with lime and zanthate added at the rates of 2.0 and 0.01 pounds per ton of ore, respectively, and produced concentrate 3 and middling 2. The tailing from the rougher operation was tabled and produced a table concentrate and tailing. The table concentrate was panned to give a pan concentrate and middling, and the latter was combined with the table tailing to produce the final tailing. Detailed and summarized results are given in Tables 6 and 7, respectively.

Referring to Table 6, concentrates 3 and 2 contained 70.00 and 3.22 per cents of the total gold and 58.50 and 5.14 per cents of the total silver, respectively. The table concentrate contained 6.71 and 0.64 per cents of the gold and silver respectively.

Referring to Table 7, the combined concentrates including 3, 2, and table contained 79.93 and 64.28 per cents of the gold and silver, respectively as a products assaying 4.08 and 18.50 ounces per ton of gold and silver respectively.

Test 3

A sample of ore weighing 2000 grams, ground to 70 per cent minus 200-mesh, was treated on a laboratory Wilfley table, which produced concentrate, middling, and tailing products. The tailing was floated with zanthate and pine oil, each added at the rate of 0.10 pounds per ton of original ore, which produced concentrate 1 and a middling. The middling was treated with the 0.10 pounds per ton each of zanthate and pine oil which produced concentrate 2 and final tailing.

Referring to Table 8, the table concentrate and middling contained 82.8 per cent of the gold. Flotation which followed tabling recovered an additional 13.9 per cent of the gold making the combined table and flotation recoveries of gold 96.7 per cent. The combined

Table 6--Detailed results of Test 2.

| | Weights, grams | Tons in 100 | Assays, ounces per ton: Gold | Silver | Tons X assays, ounces: Gold | Silver | Per cents of total: Gold | Silver |
|---|---|---|---|---|---|---|---|---|
| Heads | 2000.0 | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.00 | 100.00 |
| Conc. No. 3 | 202.1 | 10.10 | 4.72 | 22.20 | 47.56 | 224.00 | 70.00 | 58.50 |
| Conc. No. 2 | 47.7 | 2.38 | 0.92 | 8.28 | 2.19 | 19.70 | 3.22 | 5.14 |
| Table Conc. | 16.5 | .82 | 5.57 | 3.00 | 4.56 | 2.46 | 6.71 | 0.64 |
| Middling No. 1 | 792.0 | 39.60 | 0.20 | 1.49 | 7.92 | 59.00 | 2.19 | 15.40 |
| Middling No. 2 | 118.0 | 5.90 | 0.56 | 3.91 | 3.30 | 23.10 | 4.85 | 6.03 |
| Tailing | 823.7 | 41.80 | 0.06 | 1.33 | 2.47 | 54.75 | 3.64 | 14.30 |

Table 7--Summary of Table 6 results

| | Weights, grams | Tons in 100 | Assays, ounces per ton: Gold | Silver | Tons X assays, ounces: Gold | Silver | Per cents of total: Gold | Silver |
|---|---|---|---|---|---|---|---|---|
| Heads | 2000.0 | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.00 | 100.00 |
| Combined Conct. | 266.3 | 13.30 | 4.08 | 18.50 | 54.31 | 246.16 | 79.93 | 64.28 |
| Middling | 910.0 | 45.50 | 0.25 | 6.17 | 11.22 | 82.10 | 7.04 | 21.43 |
| Tailing | 823.7 | 41.80 | 0.06 | 1.33 | 2.47 | 54.75 | 3.64 | 14.30 |

Table 8--Detailed results of Test 3.

| | Weights, grams | Tons in 100 | Assays, ounces per ton: Gold | Assays, ounces per ton: Silver | Tons X assays, ounces: Gold | Tons X assays, ounces: Silver | Per cents of total: Gold | Per cents of total: Silver |
|---|---|---|---|---|---|---|---|---|
| Heads | 2000.0 | 100.0 | 0.68 | 3.83 | 68.00 | 383.0 | 100.0 | 100.0 |
| Table Conc. | 695.0 | 34.7 | 1.38 | 3.34 | 47.88 | 115.7 | 70.4 | 30.2 |
| Table Middling | 185.0 | 9.2 | 0.92 | 2.38 | 8.46 | 21.9 | 12.4 | 5.7 |
| Flot. Conc. 1 | 166.0 | 8.4 | 0.56 | 11.76 | 4.70 | 98.7 | 6.9 | 25.8 |
| Tailing | 737.0 | 36.8 | 0.06 | 2.36 | 2.21 | 86.9 | 3.3 | 22.7 |

table and flotation concentrates assayed 1.04 ounces of gold per ton.

Test 4

A sample of 2000 grams of ore, ground to 70 per cent minus 200-mesh, was treated by bulk flotation with 0.35 and 0.20 pounds per ton of zanthate and pine oil, respectively, which produced a rougher flotation concentrate and tailing. The tailing was tabled producing a table concentrate and final tailing. The flotation and table concentrates were combined and the mixture split into lots numbered A and B.

Lot A was treated by selective flotation employing 5.0 pounds of lime per ton and small amounts of zanthate and pine oil. The p H value of the water was 11.2. The results of the treatment of lot A are presented in Table 9, based on 100 tons of original ore.

Referring to Table 9, the results of the selective treatment of combined table and flotation concentrates indicated a recovery of 81.2 per cent of the gold as a concentrate assaying 1.67 ounces of gold per ton. Concentration ratio was 100 to 33.04.

Test 5.

The material used for this test was lot B of test

Table 9--Test 4 treatment of lot A.

| | Tons in 100 | Assays, ounces per ton | | Tons X assays, ounces | | Per cents of total | |
|---|---|---|---|---|---|---|---|
| | | Gold | Silver | Gold | Silver | Gold | Silver |
| Heads | 100.00 | 0.68 | 3.43 | 68.00 | 383.00 | 100.0 | 100.0 |
| Concentrate | 33.04 | 1.67 | 7.06 | 55.26 | 233.00 | 81.2 | 61.0 |
| Middling | 29.91 | 0.35 | 3.26 | 10.52 | 97.80 | 15.5 | 25.4 |
| Tailing | 37.05 | 0.06 | 1.41 | 2.22 | 52.20 | 3.3 | 13.6 |

4. Lot B was dried and ground to 95 per cent minus 200-mesh in a ball mill, after which it was treated by selective flotation with lime, zanthate, and pine oil as in test 4. The results of test 5 are given in Table 10 based on 100 tons of original ore.

Referring to Table 10, the regrinding and selective flotation treatment of the bulk and table flotation concentrate indicated a recovery of 83.4 per cent of the gold as a concentrate containing 3.88 ounces of gold per ton.

Comparing the selective treatment of combined table and flotation concentrate with and without regrinding, the results of tests 4 and 5 indicated about the same recoveries but a somewhat higher grade of product when regrinding was employed.

Test 6.

A sample of 2000 grams of ore, ground to 70 per cent minus 200-mesh, was treated on a laboratory Wilfley table, which produced concentrate, middling, and tailing products. The tailing was treated by flotation with zanthate and pine oil, each added in two stages at the total rate of 0.10 pound per ton of original ore which produced concentrate and tailing. products. The tailing was panned producing a pan

Table 10--Results of regrinding and selective flotation of concentrate.

| | Tons in 100 | Assays, ounces per ton | | Tons X assays, ounces | | Per cents of total | |
|---|---|---|---|---|---|---|---|
| | | Gold | Silver | Gold | Silver | Gold | Silver |
| Heads | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.0 | 100.0 |
| Concentrate | 14.60 | 3.88 | 17.50 | 56.60 | 255.00 | 83.4 | 66.6 |
| Middling | 48.35 | 0.19 | 1.57 | 9.18 | 75.80 | 13.3 | 19.8 |
| Tailing | 37.05 | 0.06 | 1.41 | 2.22 | 52.20 | 3.3 | 13.6 |

concentrate and final tailing. The flotation and table concentrates were combined and the mixture split into lots numbered A and B.

Lot A was treated by selective flotation employing 5.0 pounds of lime per ton and small amounts of zanthate and pine oil. The results of the treatment of lot A are presented in Table 11, based on 100 tons of original ore.

Referring to Table 11, the results of the selective treatment of combined table and flotation concentrates indicated a recovery of 73.8 per cent of the gold as a concentrate assaying 4.36 ounces of gold per ton. Concentration ratio was 100 to 11.50.

Test 7

The material used for this test was lot B of test 6. Lot B was dried and ground to 95 per cent minus 200-mesh in a ball mill, after which it was treated by selective flotation with lime, zanthate, and pine oil as in test 6. The results of test 7 are given in Table 12, based on 100 tons of original ore.

Referring to Table 12, the regrinding and selective flotation treatment of the table and bulk flotation concentrates indicated a recovery of 85.4 per cent of the gold as a concentrate containing 3.26 ounces of gold per ton.

Table 11--Test 6 treatment of lot A.

| | Tons in 100 | Assays, ounces per ton: Gold | Silver | Tons X assays, ounces: Gold | Silver | Per cents of total: Gold | Silver |
|---|---|---|---|---|---|---|---|
| Heads | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.0 | 100.0 |
| Concentrate | 11.50 | 4.36 | 17.10 | 50.14 | 196.80 | 73.8 | 51.4 |
| Middling | 47.00 | 0.29 | 2.05 | 13.62 | 96.50 | 20.0 | 25.2 |
| Pan Concentrate | 2.40 | 0.10 | 0.42 | 0.23 | 1.15 | 0.3 | 0.3 |
| Tailing | 39.10 | 0.15 | 2.26 | 4.01 | 88.55 | 5.9 | 23.1 |

Table 12--Results of regrinding and selective flotation of concentrate.

| | Tons in 100 | Assays, ounces per ton: Gold | Silver | Tons X assays, ounces: Gold | Silver | Per cents of total: Gold | Silver |
|---|---|---|---|---|---|---|---|
| Heads | 100.00 | 0.68 | 3.83 | 68.00 | 383.00 | 100.0 | 100.0 |
| Concentrate | 17.80 | 3.26 | 13.10 | 58.08 | 233.80 | 85.4 | 61.0 |
| Middling | 43.10 | 0.14 | 1.41 | 5.91 | 60.65 | 8.7 | 15.9 |
| Tailing | 39.10 | 0.15 | 2.26 | 4.01 | 88.55 | 5.9 | 23.1 |

Comparing the selective treatment of combined table and flotation concentrate with and without regrinding, the results of test 7 with regrinding indicated a greater recovery than test 6 without regrinding, but a lower grade product when regrinding was used. The difference in grade of concentrates, however, was due likely to technique rather than to difference in degree of grinding.

## CHAPTER IV. CONCLUSIONS.

The experimental results described in this paper indicated the conclusions which follow:

1- The treatment of this material by bulk flotation methods yielded a high recovery; namely, 93.3 per cent, but since practically all the pyrite was floated, the grade of concentrate was necessarily low, amounting to 1.05 ounces of gold per ton.

2- The selective flotation of bulk concentrate without regrinding yielded lower average recoveries which varied from 73.80 to 81.20 per cents, but the average grade of concentrate was increased to an average of approximately 3.43 ounces of gold per ton.

3- The selective flotation of bulk concentrate after regrinding to 95 per cent minus 200-mesh resulted in an average recovery of 84 per cent with a slightly higher grade of concentrate which averaged 3.55 ounces of gold per ton.

4- The cyanide tests indicated that the gold was essentially native in the material tested and practically completely exposed to the action of cyanide when ground to 70 per cent minus 200-mesh.