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A Study of a Carbonaceous Gold Ore

James S. Huckaba

A STUDY
OF A
CARBONACEOUS GOLD
ORE

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A Thesis
Submitted to the Department of Metallurgy
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Metallurgical Engineering

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I N T R O D U C T I O N

The presence of graphite in the ore of the Missouri-McKee Mine has made its treatment by the methods now used quite unsatisfactory. The study was undertaken to develop a new flow sheet which would give a high recovery and yet be economical enough to handle low grade material. Stamps and plates, followed by a unit flotation cell, two Wilfley tables, and a batch cyanide process (See Plate I) constitutes the present flow sheet used, the purpose of the unit cell being to remove the graphite prior to cyanidation. It is a well established fact that, if present in cyanide solutions, graphite will adsorb the gold-cyanide molecule and carry the gold out with the tailing.

The Missouri-McKee Mine is located about nine miles west of McAllister, Montana in what is known as the Washington mining district of the Tobacco Root Mountains. The ore can be typed as a highly oxidized quartz vein with a small percentage of sulphides present. A large syenite porphyry sill has invaded the country rock, which consists of Pony gneisses and shists of the Cherry Creek formation. The ore occurs in four parallel veins, two of which are on the foot and hanging wall of the sill while the other two veins follow the bedding planes of the country rock.

The problem appeared to be a very good one as none similar had been worked out as a thesis. Due to the nature of the ore it was thought advisable to proceed under the direction of both the Metallurgical and Mineral Dressing departments as the facilities necessary were combined in both.

A GENERAL METHOD OF PROCEDURE FOR ORE TESTING

(1) Obtaining a suitable and accurate sample.

(2) Determining the mineralogical composition.

(3) Chemical analysis of the ore.

(4) Determining the distribution of the valuable minerals.

(5) Determining the aggregration of valuable minerals in the ore.

(6) A study of existing flow sheets of similar ores.

(7) The drawing up of a tenative flow sheet.

(8) Test flow sheet for each type of concentration.

(9) Making a pilot mill test.

S A M P L E

About 200 pounds of the ore were available and proved ample for all purposes. The largest pieces were about 2 inches in diameter, but most of it was fine enough to pass a 1/2 inch Jones Splitter. This sample was taken from rejects at the Assay Office of the mill and was thought to give a good a composite sample of the various veins as could be obtained without extensive sampling. At least all the minerals would be present in greater or lesser amounts and thereby be taken into consideration in the concentration. The sample contained a great deal of fines due to the fact that much of it had been put through a Braum polverizer. This proved quite a drawback to good testing because of the large proportion of slimes.

The sample selected should be large enough to perform all tests and be representative of all ore to be treated.

C H E M I C A L A N A L Y S I S

The basis for the mineral analysis was taken from smelter returns, from observations of the writer while at the property, and from microscopic examination. A high consumption of cyanide led to the search for "cyanicides," that is, minerals which enter into a chemical reaction with sodium cyanide.

The regular insoluble method was used for the quartz determination. This, of course, included the graphite which was also an insoluble. The iron content was determined by the dichromate method, the lead by the molybdate method, and copper by the iodide method. Antimony and arsenic were tested for and found to be present in appreciable amounts, and their percentages found gravimetrically. The question of finding the amount of graphite seemed at first a difficult one, but by means of an electric tube furnace the graphite was oxidized to carbon dioxide, the gas caught and weighed. A five gram sample was treated to remove all the soluble matter, 2.7372 grams placed in a boat with alundum and placed in the quartz tube of the furnace. A correction had to be made for loss in weight due to the soluble material, as the 5 gram samples were reduced to 3.85 grams during digestion by acid, the results were multiplied by the factor $\frac{3.85}{5.00}$. The result thus obtained seemed to check the observations during flotation tests.

The results of the analysis are tabulated below:

Gold	0.800	oz/ton
Silver	2.5	oz/ton
Silica(insol)	77.19	%
Iron	9.9	%
Lead	1.63	%
Copper	0.05	%
Arsenic	0.49	%
Antimony	0.77	%
Graphite	0.43	%

Further qualitative work than this seemed unnecessary unless microscopic work revealed other metals in quantities large enough to have a direct effect on the concentration.

MISCROSCOPIC STUDY

A microscopic examination of most samples is made to determine the minerals present, their relative abundance, and the size of liberation of the valuable minerals from the gangue. The best results are obtained when sized portions are mounted in bakelite briquets and examined at about 100 X in reflected, oblique and polarized light.

The four important means of identifying ore minerals are: first, the observation of color, hardness, and outline as observed upon polished surfaces; second, the observation of optical properties through polarized light; third, micro-chemical tests on minute fragments; and fourth, the etch and stain reactions of certain reagents on polished surfaces. Megoscopic examination and blow pipe analysis are limited to large specimens and are of little importance in the investigation of small or rare constitutents.

FLOAT AND SINK TESTS:

In ore dressing practice, either acetylene tetrabromide (sp. gr. 2.95) or methylene iodide (sp. gr. 3.3) is used for most purposes. Either of these can be diluted with kerosene or benzene to make liquids of lower specific gravity. Benzene was used as a diluent for acetylene tetrabromide to make a liquid of specific gravity of 2.4 and 2.65. An effort was made to float the graphite (sp. gr. 2.2) from the other

components in order to have a clean portion of the material for assaying, but the desired product remained in suspension or did not float at all. The failure of the experiment was thought due to the fact that a product was being used (-65 + 140 mesh) which gave too wide a range in dimensions of the light, flat particles, and due to the filming of the graphite during wet screening much of it may have been finer than 140 mesh. Some of the graphite particles could have been locked with gangue, but none were seen when the float product was examined under a microscope. Lack of time prevented further study of this phenomenon.

Ten grams of the sized product (-65 + 140 mesh) were used to make a regular float and sink test using undiluted acetylene tetrabromide. By using a 300-ml separatory funnel excellent fractions were obtained. The sink product (weight: one and one-half grams) was used in making a briquet for microscopic examination, and the float product was examined in the granular state and then assayed.

TABULATION OF RESULTS

Assay of heads	0.83 ox. Au/ton
Assay of float	0.05 oz. Au/ton
Assay of sink (calculated)	5.27 oz. Au/ton
% Sink	15.0
% Float	85.0
Ratio of Concentration	6.67 to 1
% Recovery	95.3 %

This result cannot be taken as the overall recovery because the slimes (-200 mesh) have not been taken into con-

sideration. The one important thing shown conclusively by the assays is that the gold is in no way associated with the graphite.

BRIQUETTING

The purpose of the briquet is to hold the mineral particles firmly in place so they can be polished for examination under the microscope. It was aimed to make a cylinder of twelve cubic centimeters and 5/8 inches long, so that it would fit into the holders of the polishing machine at the School of Mines. The one and one-half grams of sink product (sp. gr. approximately 5.0) is mixed with an equal volume of -200 mesh bakelite (sp. gr. 1.27). This small portion is placed in the mold; under 15000 pounds pressure, a small cylinder 1/4 inch thick, is formed. This now solid cylinder is placed in the bottom of the larger mold and 14.24 grams of bakelite, the amount necessary to make a 12 cc briquet, is added. The mold, being electrically heated is brought to 130° C, and 10,000 pounds pressure is applied for ten minutes. The electricity is turned off, and the mold allowed to cool ten minutes at no change in pressure.

The briquet, after removing from the mold, is ground on an emery wheel to remove sharp edges and then given a preliminary grind on a glass plate with ten micron carborundum.

After the face has been brought to the proper finish in the polishing machine, the minerals are examined at 100 X

under a Bausch & Lomb metallurgical microscope. The minerals identified were:

Pyrite - - - pale yellow in color under reflected light, dark speckled under oblique light, isotropic, sharp outline, covers only a small proportion of the field.

Hematite - - gray under reflected light, red under oblique light, rough outline, covers large percentage of the field.

Quartz - - - gray under reflected light, pale green in polarized light, isotropic.

Limonite - - gray under reflected light, yellow under oblique light, interlocked with quartz.

Gold - - - -yellow, easily scratched by needle, isotropic, KCN etches black.

Metallic Iron Galena-white, cannot be scratched by a needle.

Chalcopyrite a distinctive yellow, cannot be scratched by a needle.

Bornite - - -a distinctive pink, cannot be scratched by a needle.

Garnet - - - red, distinctive crystal form.

There were other minerals present in the field, but in such small amounts that they were not identified. Microchemical tests were made for arsenic, antimony, lead, and copper; but no positive results were obtained, although chemical analysis showed they were present. An etch reaction test was performed to identify the gold.

GRINDING

All indications, from microscopic examination and amalgamation tests, seemed to indicate complete liberation of the sulfides at minus 65 mesh. The ore was crushed by rolls to minus 20 mesh and then ground to the required fineness in either iron-ball, or pebble mills; iron contamination not being considered a vital factor. Stage grinding, in the manner prescribed consists of grinding for one minute to polish the particles already fine enough, then screening out the minus size and grinding for ten minutes before again screening, the process being continued until comminution is completed. The ore was fairly easy to grind.

WATER SUPPLY

The availability of a suitable water supply is of primary consideration in milling. All natural waters contain dissolved minerals, and a discrepancy may arise in laboratory testing versus plant practice in connection with the water used in grinding and flotation.

The proper procedure is to introduce all the variables by using; first, distilled water in both grinding and flotation; second, tap water; and third, water from the mill site. As the source at the mill site is a clear mountain

stream, it was thought that tap water would closely approximate it, the grind water being saved for use in the cell.

A M A L G A M A T I O N

In an oxidized gold ore, some or all of the values occur free. In order to determine the percentage that can be removed by amalgamation, a 1000 gram portion was ground to minus 48 mesh, and one-half of it placed in a small jar mill. After an equal weight of water and 50 grams of mercury were added, the mill was placed on rolls for one hour. The mercury was then panned off, the tails sized by wet screening, and the products dried and sacked for assaying. The remaining one-half of the material was sized dry in the Ro-tap machine and served for a screen sizing assay test on the heads.

Fire assaying of the products gave the following results:

H E A D S

SCREEN SIZE (Mesh)	WT. in grams	WT.% Retained	ASSAY oz Au/ton	WT.AVERAGE	% OF TOTAL (Au)
-48 +65	14.7	3.0	0.87	0.0261	3.55
-56 +100	56.0	11.5	0.84	0.0966	13.2
-100 + 150	76.7	15.7	0.82	0.1285	17.52
-150 + 200	99.0	20.3	0.62	0.1255	17.13
-200	242.5	49.5	0.72	0.356	48.60
TOTAL	488.9	100.00		.7327	100.00

T A I L S

SCREEN SIZE (Mesh)	WT. in grams	WT. % Retained	ASSAY oz Au/ton	WT.AVERAGE	% OF TOTAL (Au)
-48 +65	39 gr.	8.02	.30	.0241	8.14
-65 +100	90	18.51	.30	.0557	18.82
-100 +150	99	20.34	0.22	.0448	15.14
-150 +200	78	16.03	0.28	.0449	15.2
-200	180	37.10	0.34	.126	42.7
TOTAL	486	100.00		.2955	100.00

These tests show conclusively that care should be taken to avoid overgrinding as the best recovery was obtained above 150 mesh. The recovery by this process is about $\frac{0.733 - 0.296}{0.733} = \frac{0.437}{0.733} = 59.8\ \%$. Due to the difficulty in getting check results when assaying an oxide ore with relatively coarse particles of free gold, the recovery can be considered only a close approximation of what would be expected in practice.

The best results cannot be expected with plates because of the tendency of the antimony in the ore to harden the amalgam. Some type of patented amalgamator where the percentage of mercury to gold is greater than on the plates would possibly work very well.

HYDRAULIC CLASSIFICATION

About fifteen pounds of minus 20 mesh were treated in the laboratory constriction plate hydraulic classifier to determine its effect upon the graphite and to show the distribution of the gold in the spigot products. Of the five products obtained, Nos. 3, 4, and 5 contained graphite, so the experiment failed to give any method of separation. The distribution of the gold is shown by the following table:

Spigot Prod.	Assay - oz Au/ton
No. 1 (coarsest)	1.30
No. 2	0.50
No. 3	0.54
No. 4	0.54
No. 5 (slimes)	0.90

These results seem to bear out a former statement by the writer that care should be taken to avoid overgrinding. The high assay of the slimes is undoubtedly due to the ease of crushing of the minerals with which the gold is associated, and their consequent appearance in the slimes. No tabling tests were performed on spigot products 1, 2, 3, and 4 because the sample had not been previously amalgamated, and the results obtained would be of little value.

FLOTATION TESTS

To determine the amenability of the ore to flotation, six tests were carried out. A number of possibilities were open for investigation; first, the production of a valueless concentrate containing all the graphite and treatment of the tails by gravity methods and cyanidation; second, the production of a bulk concentrate containing all the gold in the ore; third, the depression of the graphite and the flotation of the valuable minerals. Not sufficient work was done to make any definite statement regarding the outcome of such investigations, but the results of the tests and the conclusions drawn from them are given.

Actual flotation tests were carried on in the laboratory with the use of a Denver 500 gram and a Fagergren 600 gram cell. The pulp density was maintained as close as possible to twenty-five percent solids. The reagents were added as they should always be, in this manner; first, activator or depressant, and conditioner followed by agitation for a short time; second, collectors; third, frother. The time for a test depends largely upon the judgment of the operator. After ten minutes the froth was clean and apparently nothing more would be floated in both rougher and cleaner operations.

TEST NO. I

The object of this test was to try the feasability of floating off the graphite and leaving behind all of the gold. The collector used was oleic acid, which has enjoyed widespread preference over the other fatty acids because of the universal availability, its low cost, and its being liquid at room temperature instead of a solid. A new frothing agent, Emulsol reagents, X -1, is a substance which froths readily in amounts of 0.2 lbs. per ton of ore, producing a froth which is somewhat more watery than the usual flotation froth. Experimentors have stated that it gives a froth which is absolutely free of any of the common sulphide or non-sulphide minerals, except graphite or talc.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: Mill Steel Mesh -100 Time 1-7-7

Water: Grind; Tap Flotation; Grind & Tap

Solids; 600 Flotation cell, Fagergren

PRODUCT	WT. GRAMS	WT.%	ASSAY oz Au/ton	WT.AVERAGE	% OF THE TOTAL
Graphite conct.	54.5	9.1	1.02	.093	24.2
Tails	54.6	90.9	0.32	.291	75.8
TOTAL	600.5	100.0		.384	100.0

Reagents	Pounds per ton		
	Cond.	Rougher Conct.	Cleaner Conct.
H_2SO_4	0.2		
Oleic Acid		0.02	
X - 1	0.2		
Time, minutes	3	10	0

PH = 7.4

As the graphite obtained assayed 1.02 ounces of gold per ton, the test was not considered a success. Megascopic examination of the concentrates on a vanning plaque revealed much limonite and hemotite but no sulphides.

TEST No. 2

Two reagents recommended by the American Cyanamid Company, Reagents 301 and 208 were tried in conjunction with those used in Test 1. The graphite concentrates were removed first and the rougher concentrate in a separate operation. Reagent 301 in a Xanthate of a higher petroleum alcohol and is a strong collector for all sulphide minerals. K A X (potassium amyl xanthate) like all xanthates, is a good collector for all sulphide minerals. Aerofloat 208 is a non-frothing collector which finds its greatest application in the flotation of metallic gold, silver, and copper.

According to Gaudin in his "Flotation" the addition of sulphuric acid is beneficial as it removed inhibiting coatings from the surface of pyrite. This mineral gives maximum recovery if floated in a slightly acid circuit. The pH of the pulp was very hard to regulate and led to the belief that lime was present in the sample. The ratio of concentration was calculated on the basis of the relative weights of the cleaner concentrates and combined products. This does not have much meaning except that it gives an idea of the relative amount to be shipped to the smelter. An assay of 0.8 ounce of gold per ton of ore on the heads was used as the basis for calculating the percent recovery.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: Mill Steel Mesh -100 Time 1-7-7

Water: Grind; Tap Flotation; Grind & Tap

Solids: 600 Flotation cell, Fagergren

PRODUCT	WT. GRAMS	WT.%	ASSAY oz Au/ton	WT. AVERAGE	% of the TOTAL
Cleaner conct.	19	3.4	1.60	0.054	15.4
Midds	66	11.8	0.52	0.064	18.2
Tails	457	81.4	0.22	0.179	50.5
Graphite conct.	19	3.4	1.64	0.056	15.9
	561	100.0		0.353	100.00

Reagents	Pounds per ton			
	Cond.	Graphic Conct.	Rougher Conct.	Cleaner Conct.
H_2SO_4	0.2			
Oleic Acid		0.2		
X - 1		0.2		
301			0.05	
208			0.05	
K A X			0.10	
Time, minutes	3	10	10	10

PH = 7.8

The flotation results of this test were not very good as most of the gold was saved by amalgamation.

Percent Recovery = 76.7% Ratio of Conct. = 14.3 to 1

TEST NO. 3

A bulk concentrate was produced without the use of oleic acid and X-1. The recovery obtained closely approximated that of Test No. 2, the graphite floating readily with the sulphides.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: Mill Steel Mesh -100 Time 1-7-7

Water: Grind: Tap Flotation; Grind & Tap

Solids; 600 Flotation cell; Denver

PRODUCT	WT. GRAMS	WT. %	ASSAY oz Au/ton	WT. AVERAGE	% of the TOTAL
Cleaner conct.	14.7	2.52	3.48	0.0877	23.65
Midds	32.7	5.6	0.80	0.0448	12.05
Tails	53.7	91.88	0.26	0.2380	64.3
	584,4	100.00		0.3705	100.00

Reagents	Pounds per ton		
	Cond.	Rougher Conct.	Cleaner Conct.
H_2SO_4	0.2		
301		0.05	
208		0.05	
K A X		0.10	
Pine Oil		1 drop	
Time, minutes	3	10	10

PH = 7.6

Percent Recovery:

Amalgamation	$\frac{0.43}{0.80}$	=	53.8 %
Cleaner Conct.	$\frac{.0877}{0.80}$	=	10.96 %
Middlings	$\frac{.0448}{0.80}$	=	$\frac{5.6}{69.36}$ %

Ratio of Concentration

5844 : 14.7 as 39.7 : 1

TEST NO. 4

The object of this test was to observe the effects of starch, which was used as a depressant, and of a lowered pH.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: Mill Pebble Mesh -100 Time 1-10-10-10

Water: Grind: Tap Flotation Tap & Grind

Solids: 500 Flotation cell; Denver

PRODUCT	WT. GRAMS	WT. %	ASSAY oz Au/ton	WT. AVERAGE	% of the TOTAL
Cleaner conct.	12.7	3.19	4.52	.1442	37.7
Midds	30.2	7.6	0.68	.0517	13.5
Tails	355.2	89.11	0.22	.1870	48.8
TOTAL	398.1	100.0		.3829	100.0

Reagents	Pounds per ton		
	Cond.	Rougher Conct.	Cleaner Conct.
H_2SO_4	1.38		
Starch	0.5		
208		0.05	
301		0.05	
K A X		0.10	
Pine Oil		1 drop	
Time, minutes	5	10	10

PH = 6.9

Percent Recovery:

$\frac{42}{80} = 52.5$

$\frac{.144}{80} \quad 18.0$

$\frac{.052}{.80} \quad \frac{6.5}{77.0}\ \%$

Ratio of Conc.

$\frac{12.7}{398.2} = 31.3$ to 1

The cleaner concentrates were noticeably free from slimes but contained considerable graphite. The depression of the graphite was noticeable buy by no means complete. The depression of the graphite did not lower the recovery, and the reduced pH did not seem to increase it. The introduction of two variables into one test is not good practice, but they had no effect in this case.

TEST NO. 5

The use of this set of reagents was suggested by R. I. 3328, U. S. Bureau of Mines, Investigation No. 5. Experiments by the U. S. Bureau of Mines were conducted on a similar ore, and very good results obtained. The ore was ground to minus 65 mesh.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: Mill Pebble Mesh -100 Time 1-10-10

Water: Grind: Tap Flotation Tap & Grind

Solids: 600 Flotation cell: Fagergren

PRODUCT	WT. GRAMS	WT. %	ASSAY oz Au/ton	WT. AVERAGE	% of the TOTAL
Cleaner conct.	34.7	6.28	2.76	.1735	45.9
Midds	46.6	8.47	0.40	.0339	8.66
Tails	471.0	85.25	0.20	.171	45.44
TOTAL	552.3			.3784	100.00

Reagents	Pounds per ton		
	Cond.	Rougher Conct.	Cleaner Conct.
H_2SO_4	168		
Starch Soda	0.54		
Aero float		0.20	
K A X		.05	
Cresylic Acid		0.20	
Time, minutes	5	10	10

PH = 7.6

Percent Recovery:

$\frac{42}{80} = 52.5$

$\frac{.17}{.80} = 21.3$

$\frac{.04}{.80} = \frac{5.0}{78.8}\ \%$

Ratio of Conct.

552.3 : 34.9 as 15.9 : 1

The graphite was not noticeably depressed, and the recovery the same as in the preceding tests.

TEST NO. 6

The same reagents were used as in Test No. 2 with the exception of reagent 639, which is a special depressant for graphite developed by the American Cyanamid Company. Sufficient sulphuric acid was added to bring the pH down to 6.9. The grind was to minus 65 mesh.

FLOTATION MEMORANDUM

Grind:
Primary 20 mesh Final: MillPebble Mesh -65 Time 1-10-10

Water: Grind: Tap Flotation Tap & Grind

Solids: 600 Flotation cell: Fagergren

PRODUCT	WT.GRAMS	WT. %	ASSAY oz Au/ton	WT.AVERAGE	% of the TOTAL
Cleaner conct.	18 gr.	3.39	4.521	.1531	42.2
Midds	18.8 gr.	3.51	.66	.0232	6.4
Tails	492.0	93.1	.20	.186	51.4
TOTAL				.3623	100.0

Reagents	Pounds per ton		
	Cond.	Rougher Conct.	Cleaner Conct.
H_2SO_4	24		
639	0.4		
301		0.05	
208		0.05	
K A X		0.10	
Time, minutes	5	10	10

PH = 6.9

Percent Recovery:

$$\text{Amalgamation } \frac{.44}{.80} = 55.$$

$$\text{Flot. C. Conc } \frac{153}{.80} = 19.1$$

$$\text{Flot. Medds } \frac{023}{.80} = \frac{2.9}{77.0}$$

Ratio of Concentration:

528.8 : 18 as 29.3 : 1

There was a noticeable depression of the graphite. The cleaner concentrates were almost free of slimes and contained only about 5 per cent graphite. These concentrates were very high grade, and the recovery was high.

FLOAT AND SINK OF TAILS

By heavy liquid separation on the tails of flotation test No. 2, the results tabulated below were obtained:

Screen Size Test

Size-Mesh	Wt.	Weight 0/0
-100 + 150	75 grams	17.25
-100 + 200	54.7 "	12.55
-200	305.3 "	70.2
	435.0 "	100.00

-100 + 150

Product	Assay oz Au/ton	Wt.	Wt. %	Wt. Average
Sink	1.00	4.3	10.8	.108
Float	0.06	35.4	89.2	.054
		39.7	100.0	.162

Assay 0.162 oz Au/ton of ore

-150 + 200

Product	Assay oz Au/ton	Wt. Grams	Wt. %	Wt. Average
Sink	1.10	4.6	11.9	.131
Float	.03	3.4	88.1	.026
		38.6	100.0	.157

Assay 0.157 oz. Au/bon of ore

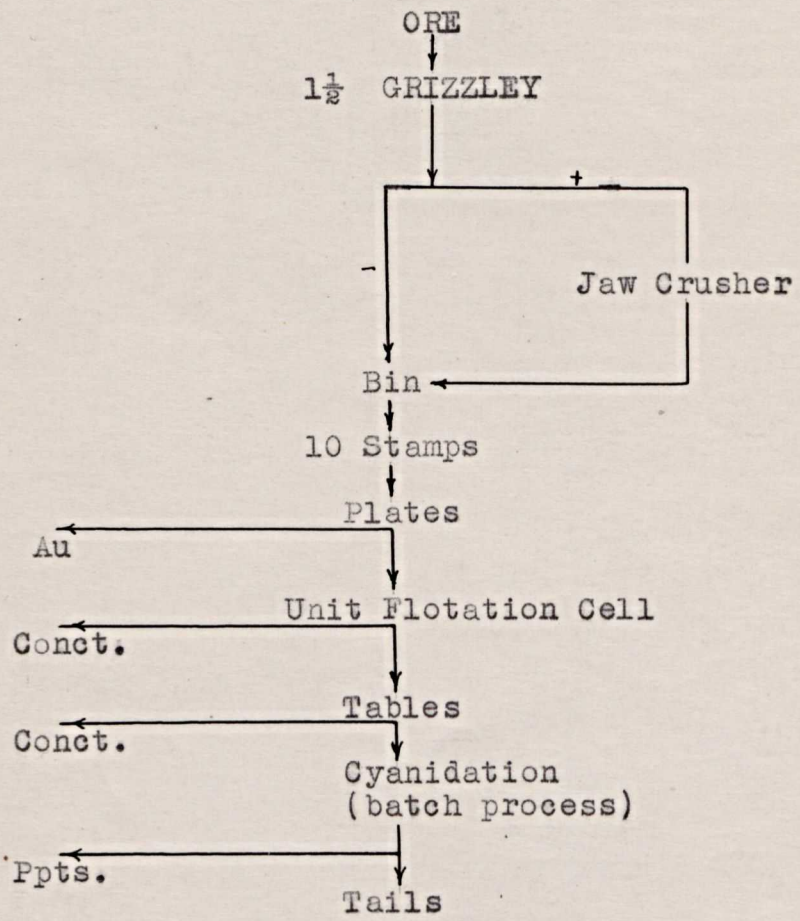
These results show that the values left in the coarser sizes are contained in the heavier minerals and can be saved by gravity concentration. The large proportion of slimes, which would not be present in plant practice, would have to be treated on slime tables or by cyanidation. The assay on the tails before sizing was 0.22 ounces of Au per ton of ore, and by inspection it can be seen that the slimes would assay higher

than calculated assays of the two sizes.

Microscopic examination of the sink did not show any sulphides. Quartz, lemonite, hemotite, garnet graphite, and a number of unidentified minerals were present.

P L A T E I

PRESENT FLOW SHEET



CONCLUSIONS

Laboratory flotation testing is an emperical art rather than a science, while manipulative procedures may be standardized, it is difficult for the beginner to obtain good results. None of the results obtained in flotation tests should be taken as conclusive until further testing work has been done. It is entirely possible that a high recovery can be obtained by amalgamation and flotation alone but time did not permit the writer to reach such results.

A definite conclusion that the graphite is in no way associated with the gold can be reached. The graphite free tails of test No. 1 and No. 2 indicated that cyanidation could be applied successfully if ample cell capacity is used.

In the deslimed material, a high recovery can be made by gravity concentration. This is shown by the assays of products of the float and sink tests. The discovery of several "cyanicides" showed the reason for high cyanide consumption.

While not many positive results were reached, the real value lies in the fact that this work gives the student practice in tackling any kind of a problem.

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