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item 1

NBM
File 13

GETCHELL MINE, INC.

RED HOUSE, NEVADA

SUMMARY
OF

METALLURGICAL DATA

1936 TO 1946

F. W. MCQUISTON, JR.
MARCH 5, 1946

TABLE of CONTENTS

American Cyanamid Company — Started in 1958 new cyanide tests with a new cyanide solution waste product which has selective action in presence of arsenic — 1st series of tests indicated recovery between 75 & 80% Au

1936-10 (2)
ROASTING - CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

<u>Purpose of Investigation:</u>

To determine the effects of roasting.

<u>Procedure and Results:</u>

The following products were roasted 60 minutes at 520°C.

Test No.	Roasting Conditions	Mesh Size	Final Grind	Assays Oz Au/ton Heads	Tails	%Ext.
4.	Roasting flotation tailings	100	100	.22	.04	81.8
5.	Direct Roasting of ore	20	20	.22	.09	60.2
5a.	" " " "	20	100	.23	.07	68.5

<u>Summary:</u>

Refractory gold is either locked up as an insoluble complex formed by roasting or is an alteration product of sulfides. If gold is encased in silica liberation will be difficult.

1936-11

<u>Purpose of Investigation:</u>

A follow up on previous tests with a higher temperature roast.

<u>Procedure and Results:</u>

Roasts were made for 90 minutes.

Test No.	Roasting Conditions	Size	Temp. °C	Final Grind	Assays Oz Au/ton Heads	Tails	%Ext.
9.	Cyanidation of calcine	20	660	20	.22	.075	65.9
9b.	" " "	20	660	100	.227	.065	68.7
10.	" " "	20	800	20	.228	.077	66.0
10b.	" " "	20	800	100	.24	.054	68.4
	Arsenic Minerals Floated Out						
11.	" without grinding	20	620	20	.233	.075	67.8
11a.	" with grinding	20	620	100	.225	.062	72.4
12a.	" without grinding	35	620	200	.234	.065	72.2
12b.	" with grinding	35	620	100	.227	.055	75.7

<u>Summary:</u>

Grinding the calcine to minus 100 mesh improves gold extraction.

Roasting the ore followed by fine grinding and cyanidation gives a 70% extraction.

1936-10 (2)
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1937-2
ROASTING - CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Purpose of Investigation:

To determine the effect of grinding the roaster feed before roasting.

Procedure and Results:

Test No.	Roasting Conditions	Size	Time Min.	Temp. °C	Final Grind	Results Assays Oz Au/ton Heads	 Tails	 % Ext.
21	Grind to 200 Mesh	200	90	650	200	.237	.07	70.5
21a	Grind to 200 Mesh	200	90	650	200	.23	.06	73.9

Summary:

Final cyanide residue from cyanidation of flotation tailings contain some amount of gold as the residue from roasting followed by cyanidation.

1937-3-1

Purpose of Investigation:

Roasting under oxidizing conditions.

Test No.	Size	Roasting Conditions Time Min.	 Temp. °C	Final Grind	Results Assays Oz Au/ton Heads	 Tails	 % Ext.
2	10	60	450	200	.835	.395	52.7
3	10	75	670	200	.675	.125	81.4
5	10	60	470	200	.34	.14	58.5
6	10	60	550	200	.35	.08	77.0
7	10	60	670	200	.35	.08	77.1
8	10	60	800	200	.37	.075	79.6

Summary:

Ores should be roasted to a minimum temperature of 600°C, however a temperature of 700° is probably best.

1937-3-2

Purpose of Investigation:

To determine the best size at which to roast.

1937-3-2
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure and Results:

Test		Roasting Conditions			Results		
		Time	Temp.	Final	Assays	Oz Au/ton	
No.	Size	Min.	°C	Grind	Heads	Tails	%Ext.
1	10	90	710	200	.74	.13	82.5
2	8	90	710	200	.68	.13	80.8
3	6	90	710	200	.68	.14	79.6
4	¼"	90	710		.68	.125	81.8

Summary:
The results of these laboratory roasting and cyanidation tests show that feed as coarse as ¼" amy be roasted satisfactorily as feed ground to 10 mesh.

Final cyanide residues from direct cyanidation of flotation tails contains about the same amount of gold as the cyanide residues from the cyanidation of calcines.

1937-4

Purpose of Investigation:
A 600 pound charge was roasted in a Herreshoff furnace for five hours. Each hour of roast was kept separate.

Procedure and Results:
The ¼" feed was roasted 5 hours with the roasting temperature increased slowly to a high end temperature.

Test	Assays	Oz Au/ton	
No.	Heads	Tails	%Ext.
10	.54	.115	78.8
11	.56	.115	79.9
12	.57	.12	79.1
13	.59	.11	81.3
14	.60	.115	81.0

Summary:
A continuous roast gives the same results as long time roasting.

Purpose of Investigation:
To determine the best size of roaster feed.

1937-4-2
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure:

The following sizes were roasted 100 minutes at 700°C. The calcine was ground to minus 200 mesh and cyanided for 48 hours with a 1.0 lb. NaCN solution.

Results:

Test	Roaster Feed	Assays	Oz Au/ton	
No.	Size	Heads	Tails	%Ext.
15	1/4"	.56	.12	78.5
16	1/2"	.54	.125	76.9
17	3/4"	.61	.15	75.4
18	1"	.60	.155	74.0

Summary:

Test results show rapidly increasing amounts of gold in the cyanide residues as the size of the roaster feed increases from minus 1/2" to minus 1" in size. The results with minus 1/4" and minus 1/2" roaster feed are about the same so it would probably be economically advantageous to use minus 1/2" material for roaster feed.

Purpose of Investigation:

To determine the effects of pretreating the calcines prior to cyanidation.

Procedure and Results:

The ore was roasted 90 minutes at 700°C.

Test		Roasting Conditions		Results		
			Final	Assays	Oz Au/ton	
No.	Pretreatment of Calcines	Size	Grind	Heads	Tails	%Ext.
3a	H_2SO_4 10%; NaCL 25% 48 Hrs. Agitation	20	100	.69	.095	86.2
3b	Acid Brine	20	None	.67	.095	85.9
4a	H_2SO_4 2% 48 Hr. Leach	20	100	.69	.10	85.5
4b	"	20	None	.68	.055	91.9
A	NaCl 5% mixed in feed for roast	1/4"	200	.612	.16	73.8
B	Calcine treated with chlorine gas	8	80	.685	.152	77.8
23	H_2SO_4 2% 24 Hr. Leach	10	200	.665	.06	90.0
24	" " " " "	10	100	.655	.075	88.5
25	" " " " "	10	65	.616	.145	76.4
26	" " plus Fe_2SO_4 2% 24 Hr. Leach	1/4"	100	.662	.055	91.6
27	" " " " " " " "	1/4"	65	.666	.065	90.2
28	" " " " " " " "	1/4"	35	.64	.095	85.1
33	" " one hour leach	10	80	.64	.105	83.6
34	" " 24 " "	10	80	.64	.075	88.3
35	" 5% 1 " "	10	100	.63	.075	88.1
36	" " 24 " "	10	100	.66	.06	90.9
29	$NaHCO_3$ 5% boiled 100m calcine	10	100	.61	.115	81.2
30	HCl 1% boiled 100m calcine	10	100	.62	.10	83.9

(continued on next page)

1937-4-2
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure and Results: (Continued)

		Roasting Conditions			Results	
Test			Final	Assays	Oz Au/ton	
No.	Pretreatment of Calcines	Size	Grind	Heads	Tails	% Ext.
37	NaOH for cyanide protective alk.	10	100	.605	.10	83.5
37a	" 10 NaCN/ton sol.	10	100	.59	.095	83.9
38	Na_2CO_3 for cyanide protective alk.	10	100	.61	.12	80.3
38a	" 10 NaCN/ton sol.	10	100	.62	.11	82.3
39	CaO for cyanide protective alk.	10	100	.605	.13	78.5
39a	" " " " "	10	100	.62	.12	80.7
41	Roasted with 1% $Ca(COH)_2$	1/4"	100	.635	.115	81.8
42	" " 2% "	1/4"	100	.59	.11	81.3
43	" " 5% "	1/4	100	.565	.095	83.2
44	Roasted with 1% 100m coal	1/4"	100	.525	.105	80.0
45	" " 2% " "	1/4"	100	.535	.10	80.4
46	" " 5% " "	1/4"	100	.555	.095	82.9
47	Low temperature roast 330°C - 60 min.	20	100	.521	.20	61.5

Summary:

The cause of some of the gold to be refractory to cyanidation may be: 1. Coated with some substance impervious to cyanidation. 2. Associated with some substance present in the calcine so the gold is not free to dissolve. 3. A coating is formed on some of the gold during cyanidation by reaction of some constituent of the calcine with substances present in the cyanide solution.

1937-5

Purpose of Investigation:

To determine the effects of pretreating the calcines prior to cyanidation.

Procedure and Results:

The ore was roasted 90 minutes at 700°C.

		Roasting Conditions			Results	
Test			Final	Assays	Oz Au/ton	
No.	Pretreatment of Calcines	Size	Grind	Heads	Tails	% Ext.
48	NaOH 80 lbs/ton in cyanidation	1/4"	100	.575	.10	82.0
49	H_2SO_4 5% 96 hr. leach at 20m	1/4"	20	.615	.055	91.0
49	Acid residue ground		150	.64	.05	92.2
49a	H_2SO_4 5% 48 hr. leach at 1/4"	1/4"	None	.645	.065	89.9
49b	Acid residue ground	1/4"	150	.635	.055	91.3
50a	H_2SO_4 5% 96 hr. leach at 1/4"	1/4"	None	.63	.06	90.5
50b	Acid residue ground	1/4"	150	.61	.065	89.3

(tests continued on next page)

Procedure and Results: (continued)

Test No.	Pretreatment of Calcines	Roasting Conditions Size	Final Grind	Assays Heads	Results Oz Au/ton Tails	%Ext.
56	Agitation by pump to introduce air	1/4"	100	.575	.07	87.8
57	Na_2O_2 8 lbs/ton in cyanidation	1/4"	100	.575	.105	81.7
65	Aerated in Sub-A cell 48 hrs.	1/4"	100	.575	.13	77.5
67	Pump circulation—NaCN con. high	1/4"	100	.575	.115	80.0
58	Cyanidation 48 hrs. in 2 lb NaCN sol.	1/4"	20	.59	.14	76.2
59	" " " " " " "	1/4"	48	.60	.12	80.0
60	" " " " " " "	1/4"	200	.60	.115	80.8
61	" " " " " " "	1/4"	200	.60	.105	82.5
73	Pump circulation; 48 hr. cyanidation	1/4"	100	.60	.13	78.4
74	Hg 5gm in cyanidation	1/4"	100	.593	.13	78.0
75	Mercuric cyanide	1/4"	100	.613	.13	78.6
78	H_2SO_4 3% leached 5 days at 1/4"	1/4"				
78a	Acid residue cyanided 48 hrs.		20	.62	.07	88.6
78b	" " " with HgCN		20	.613	.07	88.6
78c	" " "		48	.576	.075	87.0
78d	" " " with HgCN		48	.578	.07	88.2
78e	" " "		100	.593	.075	87.4
78f	" " " with HgCN		100	.592	.075	87.4
78g	Metallic mercury used		100	.604	.075	87.6
55	Roasted at 350°C; non-magnetic portion reroasted at 700°C; cyanided	20	150	.515	.125	75.7
	The ore was roasted 155 minutes at 800°C.					
63	Cyanidation 72 hrs. 2 lb NaCN sol.	20	None	.623	.195	66.6
63a	" 48 hrs. " " "	20	100	.589	.185	68.5
64a	" 72 hrs. " " "	1/2"	20	.586	.145	73.3
64b	" 48 hrs. " " "	1/2"	65	.542	.14	74.2
64c	" 48 hrs. " " "	1/2"	100	.564	.14	75.2

Summary:

(1) The addition of an excess of ammonia to the pulp during cyanidation does not materially improve the extraction.

(2) Treatment of the calcine with H_2SO_4 prior to cyanidation increases the extraction about 10%. That is, the average extraction by cyanidation of acid-treated calcine is about 90%. Acid treatment may be applied to calcine as coarse as 1/4 inch by percolation and the acid treated residue may be cyanided as coarse as 20 mesh. The lower limit of acid strength which is effective has not been determined.

(3) Low temperature roasting, removal of magnetic portion and reroasting of non-magnetic portion to about 700°C. did not produce a calcine as amenable to cyanidation as the straight 700°C roast.

1937-5
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Summary: (Continued)
(4) Extreme oxidation of pulp during cyanidation, accomplished by means of a centrifugal pump, by flotation machine, or by a chemical oxidizer, gave erratic results and it indicated that such procedure will not be beneficial. These tests were made on calcined sulfide ore.

(5) Direct cyanidation of calcined sulfide ore ground to different sizes showed that the calcine should be ground to at least 48 mesh for best economic results. These results were checked by a sizing assay test on a composite sample of cyanide residue.

(6) A high-temperature (800°C) long period (2 hours and 35 minutes) roast on sulfied ore produces a calcine less amenable to direct cyanidation than the calcine from the usual (700°C, 1 hour and 30 minute) roast.

(7) The use of mercury either as a cyanide or as metallic mercury is of no benefit in the cyanidation of acid treated calcines.

(8) Sulfuric acid solutions from calcine treatment shows arsenic and iron to be the main elements in the acid wash. There were also present detectable amounts of calcium, aluminum, molybdenum, vanadium and magnesium. Copper, lead, silicon and nickle were also present.

From this determination it appears as if iron and arsenic might be the troublesome coating removed from the gold by the acid wash.

1937-7

Purpose of Investigation:
To determine if the sulfuric acid strength could be brought back to 3% strength and reused.

Procedure:
Decanted acid solutions from test 78 were brought to a 3% strength and a series of tests run at different mesh calcine grinds.

Results:
The extraction was 12% lower than extractions with fresh acids. Weak acid solutions cannot be reused for leaching unless some method of purifying the acid can be devised.

Purpose of Investigation:
To determine gold extractions of a calcine produced from a rotary furnace.

1937-7
ROASTING-CYANIDATION
U. S. BUREAU OF MINES - Leaver, Woolf, Jackson

Procedure and Results:

Test No.	Roasting Conditions			Results		
		Temp	Final	Assays Oz Au/ton		
	Size	°F	Grind	Heads	Tails	%Ext.
82a	1/2"	1000	65	.59	.135	77.2
82b	1/2"	1250	65	.585	.12	79.5
82c	1/2"	1500	65	.58	.12	74.2

Summary:

These results again show that 1250°F or 700°C is the best temperature for roasting.

Purpose of Investigation:

To determine the effects of pretreatment on a 1250°F calcine.

Procedure and Results:

Roasting in a rotary furnace was made on a 1/2" calcine at 1250°F.

Test No.	Pretreatment of Calcines	Final Grind	Heads	Results Tails	%Ext.
84	H_2SO_4 2% Agitation at 1/2" 22 hrs.	20	.592	.075	87.1
85	" " same; grind in lime water	200	.567	.055	90.2
88	" " Agitation at 20 mesh	20	.604	.075	87.5
89	" " same; grind in lime water	200	.595	.06	89.8
86	Water agitation at 1/2"	20	.589	.11	81.2
87	" " same; grind in lime water	200	.620	.09	85.3
90	" " at 20m	20	.580	.11	80.5
91	" " same; grind in lime water	200	.562	.085	84.7
92	" " at 100m	100	.573	.13	80.5
93	" " at 200m	200	.573	.10	82.4
94	Grind in NaCN Solution	200	.547	.093	82.2

Summary:

Calcines at 1/2" maximum size gives as good results by acid treatment followed by finer grinding for cyanidation as are obtained if the calcine is crushed to 20 mesh before acid treatment. Grinding of the acid treated residue to minus 200 mesh for cyanidation increases the extraction approximately 3% over that obtained by cyanidation of the acid treated residue at 20 mesh.

Purpose of Investigation:

To determine the effect of quenching hot calcines.

1937-7
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure and Results:

1/2" ore was roasted 85 minutes at 700°C. The hot calcines were quenched in the following solutions at 1/2".

Test No.	Pretreatment of Calcines	Final Grind	Results Assays Oz Au/ton Heads	Tails	%Ext.
96b	H_2SO_4 1% 1:1 agitation for 22 hrs.	20	.51	.10	80.4
96c	" " " " " " "	200	.537	.10	81.3
97a	Water agitation	20	.556	.125	77.5
97c	" " ground in lime	200	.568	.115	79.9
98a	H_2SO_4 1% agitation for 16 hrs.	20	.553	.11	79.8
98c	" " " " " "	200	.545	.11	79.7
99b	Water agitation " " "	20	.495	.12	75.8
99c	" " ground in lime	200	.500	.105	79.0
100b	H_2SO_4 1% no agitation	20	.530	.115	78.5
100c	" " " " ground in lime	200	.523	.105	80.0

Summary:

Quenching of the calcine, in general, increases slightly the extraction of the gold and that quenching in 1% H_2SO_4 is somewhat more effective than quenching in water. Extractions from quenchings are not nearly so good as if calcine is leached for four days with 2% H_2SO_4 or agitated 24 hours with 2% H_2SO_4 solution.

Treatment of the calcine at either 20 mesh or at 1/2" with a 2% H_2SO_4 solution followed by washing and treatment with cyanide at 20 mesh gives an extraction of 87%. The same acid treatment followed by cyanidation after grinding to 200 mesh gives an extraction of 90%.

It is definitely established that preliminary treatment either with water or acid is more effective if applied to coarse calcine.

1937-9

Purpose of Investigation:

To determine effects of pretreating a calcine roasted at 1000°F.

Procedure and Results:

After crushing to 1/2" the ore was roasted at 1000°F in a rotary furnace. The calcines were ground to minus 150 mesh for cyanidation. Pretreatment at 1/2".

Test No.	Pretreatment of Calcines	Results Assays Oz Au/ton Heads	Tails	%Ext.
108	Water agitation at 40°C for 24 hrs. Dil. 1:1	.561	.12	78.6
109	" " " " " " " Dil. 2:1	.571	.115	79.8

(tests continued on next page)

1937-9
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure and Results: (continued)

Test No.	Pretreatment of Calcines			Results Assays Oz Au/ton Heads	Tails	% Ext.
110	H_2SO_4 1% agitation at 40°C for 24 hrs.	Dil.	1:1	.61	.07	88.5
111	" 1% " " " " " "	"	2:1	.57	.065	88.6
112	" 2% " " " " " "	"	1:1	.55	.04	92.7
113	" 2% " " " " " "	"	2:1	.595	.045	92.4
114	Agitation at 150m in 2 lb. NaCN 48 hrs.	"	4:1	.579	.105	81.8
114a	Water agitation at 40°C for 24 hrs.	"	1:1	.573	.11	80.8
114c	" " " " " " "	"	2:1	.524	.10	80.9
114e	H_2SO_4 1½% " " " " " "	"	1:1	.545	.085	84.4
114g	" " " " " " " "	"	2:1	.554	.065	88.2
114i	" 2% " " " " " "	"	1:1	.522	.06	88.5
114k	" " " " " " " "	"	2:1	.59	.06	89.8

Summary:
The results show that the calcine produced in a rotary furnace at maximum temperatures of 1000°F is especially amenable to cyanidation after acid treatment. Direct cyanidation or cyanidation after treatment with warm water does not give as high extraction of the gold as was obtained by the same method of treatment on the calcine produced in a rotary furnace at a maximum temperature of 1250°F.

Tests show definitely that preliminary treatment with 2% H_2SO_4 solution is effective in raising the extraction to about 90%. Also preliminary treatment with warm water is effective in raising the extraction to about 85%. Both acid and water treatments are more effective if applied to relatively coarse calcines and may be applied to the calcine as it comes from the furnace without further grinding.

Sulfuric acid, which had been used for leaching calcines, was allowed to stand two days during which a voluminous bulky white percipitate formed. The percipitate contained chiefly iron and arsenic and some lead, silica, molybdenum and aluminum, and traces of antimony were found. The solution became saturated with arsenic so that it was not effective when used a second time.

Purpose of Investigation:
To determine if an oxidizing roast gave a calcine more amenable to cyanidation.

Procedure and Results:
1/4" ore was given an oxidizing roast for 90 minutes at 600°C. The calcine was ground to minus 150 mesh for cyanidation.

1937-9
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure and Results: (continued)

Test No.	Pretreatment of Calcines		Assays Heads	Results Oz Au/ton Tails	Ext.
115	Cyanided in 2 lb. NaCN sol. for 48 hrs.		.522	.13	75.2
115b	Water agitation at 40°C for 18 hrs.	Dil. 1:1	.533	.14	73.7
115d	" " " " " "	Dil. 2:1	.527	.14	73.5
115f	H_2SO_4 1% " " " " "	Dil. 1:1	.543	.14	74.2
115g	" " " " " "	Dil. 2:1	.551	.135	75.7
115j	" 2% " " " " "	Dil. 1:1	.535	.145	73.1
115l	" " " " " "	Dil. 2:1	.535	.12	77.6

The calcine from 115 roasted in an externally fired rotary furnace. The temperature was raised to 630°C before adding any gases; thereafter, for 90 minutes a mixture of air and SO_2 was passed through in contact with the charge. The temperature varied from 440°C to 610°C. Calcine was ground to minus 150 mesh for cyanidation.

Test No.	Pretreatment of Calcines		Heads	Tails	Ext.
116	Cyanided in 2 lb. NaCN sol. for 48 hrs.		.535	.095	82.3
116b	Water agitation at 40°C for 24 hrs.	Dil. 1:1	.549	.095	82.5
116d	" " " " " " "	Dil. 2:1	.534	.09	83.2
116f	H_2SO_4 1% " " " " " "	Dil. 1:1	.550	.125	77.3
116h	" 1% " " " " " "	Dil. 2:1	.522	.105	79.9
116j	" 2% " " " " " "	Dil. 1:1	.538	.10	81.3
116m	" 2% " " " " " "	Dil. 2:1	.590	.065	88.2

Summary:

To date work shows that roasting for 1½ hours to a maximum temperature of approximately 700°C under oxidizing conditions with fairly close control of the temperature during the first hour of the roast consistently produces a calcine that will allow an extraction of 80% by direct cyanidation, or approximately 90% after preliminary treatment with sulfuric acid.

1937-10

Purpose of Investigation:

To determine if a 1500°F roast would give a good extraction after preliminary treatment.

Procedure and Results:

1/2" ore was roasted 90 minutes at 1500°F. The calcine was ground to minus 150 mesh for cyanidation. Pretreatment of calcine was at 1/2" size.

			Results		
			Assays	Oz Au/ton	
Test No.	Pretreatment of Calcines		Heads	Tails	Ext.
117	Water agitation at 40°C for 24 hrs.	Dil. 1:1	.529	.12	77.3
117b	" " " " " " "	Dil. 2:1	.565	.12	78.7
117d	H_2SO_4 1% " " " " " "	Dil. 1:1	.563	.12	78.7
117f	" " " " " " " "	Dil. 2:1	.647	.12	80.7
117h	" 2% " " " " " "	Dil. 1:1	.547	.125	78.6
117j	" " " " " " " "	Dil. 2:1	.539	.08	85.1

Summary:

These results show the calcine from the 1500°F roast in the rotary-type furnace is not as amenable to preliminary treatment as calcine from the 1000°F to 1250°F roasts.

Purpose of Investigation:

Former tests on a 1250°F calcine showed that preliminary treatment with warm water followed by cyanidation gave an extraction of about 85%. Since this is the only calcine that has been materially benefited by preliminary water treatment tests 119-119a were made to check these previous results. Treatment at the Getchell Mine is to be as follows;

Calcine ground in water; thickened; partially washed. Soda ash to thickened pulp; agitated; dewatered; cyanidation.

Procedure and Results:

1/2" ore roasted at 1250°F. The calcine was pretreated at 1/2". The calcine was ground to minus 200 mesh for cyanidation.

			Results		
			Assays	Oz Au/ton	
Test No.	Pretreatment of Calcines		Heads	Tails	Ext.
119	Water agitation at 40°C for 24 hrs.	Dil. 2:1	.553	.085	84.6
120	Water grind; wash; Soda Ash 2% sol. agitation 20 hrs. at 40°C; filtered; cyanidation.		.547	.085	84.4
	These results show that Soda Ash is no more effective than a water wash. They show water is effective on a 1250°F Calcine.				
121	1/4" ore roasted at 600°C and pretreated. Grind for cyanidation was minus 200 mesh.				
121b	Water agitation at 40°C for 21 hrs.	Dil. 2:1	.594	.12	79.8
121c	H_2SO_4 1% " " " " " "	Dil. 2:1	.63	.065	89.7
121e	" 2%	Dil. 2:1	.639	.04	93.6

1937-10
ROASTING-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Summary:

These results show a water treatment is not effective, but sulfuric acid in a 2% solution is very effective.

Purpose of Investigation:

To determine effect of roasting in an atmosphere of sulfur dioxide.

Procedure and Results:

1/4" ore was roasted in an atmosphere of sulfur dioxide. 1/3 SO_2 and 2/3 air passed through the furnace during the roast. Roasting time was 90 minutes at a temperature of 650°C. The calcine assayed 0.95% S and 0.10% SO_4. The calcines were ground to minus 200 mesh.

Test No.	Pretreatment of Calcines at 1/4"		Results Assays Oz Au/ton Heads	Tails	%Ext.
124	Water agitation at 40°C for 21 hrs. at Dil.	2:1	.59	.10	83.0
124d	H_2SO_4 1% " " " " " " " " "	1:1	.60	.08	86.7
124f	" 1% " " " " " " " " "	2:1	.66	.065	90.1
124j	" 2% " " " " " " " " "	1:1	.675	.06	91.1
124l	" 2% " " " " " " " " "	2:1	.69	.055	92.0

1937-12

Purpose of Investigation:

To roast in presence of excess SO_2.

Procedure and Results:

A calcine was re-roasted in the presence of SO_2 for one hour at 600°C under oxidizing conditions in a muffle furnace. The feed was 1/4". Pretreatment of the calcine was at 40°C for 24 hours at a 2:1 dilution. Calcines were then ground to minus 200 mesh and agitated 24 hours.

Test No.	Pretreatment of Calcines	Results Assays Oz Au/ton Heads	Tails	%Ext.
125b	Water wash	.645	.065	89.9
125d	H_2SO_4 1%	.625	.05	92.0
125f	" 2%	.705	.05	92.8
126b	Water (Single SO_2 Roast)	.535	.08	85.0
126d	Trona 5%	.485	.08	85.5
126f	H_2SO_4 2%	.535	.045	91.6
127b	Water (Reroast of 126)	.53	.06	88.7
127d	Trona 5%	.46	.05	89.1
127f	H_2SO_4 2%	.50	.04	92.0

Summary:

The results of these two series of tests, 126 and 127, show first that roasting in the presence of excess sulfur dioxide followed by a partial oxidizing roast produces a calcine, which, after treatment with warm water, can be cyanided with an extraction of about 85% of the gold with relatively low cyanide loss. Secondly, the results show that if the calcine from the sulfating roast is further roasted to obtain more complete oxidation, the extraction by cyanidation after preliminary warm water treatment is close to 90% of the gold. Use of a trona solution for preliminary treatment of the calcine appears to be of no particular benefit over the warm water treatment. Treatment of the calcine with sulfuric acid solution still produces a residue more amenable to cyanidation than that produced from the water treatment. However, the difference in extraction is not very much in the case of this calcine and the additional lime and cyanide consumption for an acid treated residue will offset in part the small increase in gold extraction.

In general, the results of this type of treatment on the Getchell ore, that is roasting in an excess of sulfur dioxide to obtain sulfating conditions followed by roasting under oxidizing conditions, indicate that if this method can be worked out in a commercial manner it will mean approximately 10% increase in the gold extracted from the sulfide ore. That is, a warm water wash for a calcine of this type prepares it for an extraction of about 90% of the gold by cyanidation, whereas in the straight oxidizing type of roast it is necessary to acid treat the calcine in order to produce a residue from which 90% of the gold can be extracted by cyanidation.

1938-I

Purpose of Investigation:

To further determine benefits from re-roasting.

Procedure and Results:

A 1/4" feed was given an oxidizing roast for 120 minutes at 600°C. Loss of weight was 5.8%. This calcine was re-roasted for 180 minutes at 650°C with equal parts of air and SO_2. (Oxidizing preceeds sulfating.) The calcine after treatment was ground to minus 200 mesh and agitated with a 2.0 lb. NaCN solution for 48 hours. Pretreatment was for 24 hours at 2:1 dilution.

Test No.	Pretreatment of Calcines	Results Assays Oz Au/ton Heads	 Tails	 % Ext.
128b	Direct cyanidation	.547	.08	85.3
128d	Water agitation wash	.53	.07	86.8
128f	H_2SO_4 2%	.53	.05	90.4
	Roasting conditions were reversed as the oxidizing roast was first; this was followed by a sulfating roast.			
129c	Direct cyanidation	.495	.065	86.8
129e	Water agitation wash	.53	.065	84.9
129f	H_2SO_4 2%	.546	.045	91.1
129h	Water	.505	.09	81.2
129i	H_2SO_4 2%	.55	.05	90.9

1938-1

ROASTING-CYANIDATION

U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Summary:

The gold extraction is not as high as the tests with a sulfating roast followed by an oxidizing roast. Sulfating has the merit of producing a calcine less refractory to direct cyanidation.

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Calcine cyanidation residue sizing test. A composite sample of residues from roast cyanidation test on a 0.61 ounce head.

Results:

Products	Weight %	Assays Oz. Au/ton	Distribution %Gold
Heads	100.00	.114	100.00
Plus 200 mesh	11.12	.095	9.29
200/300	16.93	.100	14.87
Minus 300 mesh	71.95	.120	75.84

Summary:

The results of this test shows some concentration of gold in the minus 300 mesh size. It also shows a grind as fine as 200 mesh is not necessary. It indicates that the gold in the residue is coated or alloyed to retard or prevent its dissolution in cyanide.

Purpose of Investigation:

To determine how Getchell Plant calcines responded to pretreatment in the laboratory.

Procedure:

Ore for all tests roasted at minus one inch in the plant kilns.

(1) Calcine crushed to minus 1/2" then agitated 24 hours at 2:1 with a 2% H_2SO_4 solution. Filtered, washed, ground to minus 65 mesh in cyanide solution, agitated at 3:1 for 24 hours.

(2) Same as #1 except water used as a wash prior to cyanidation.

(3) Calcine as delivered from kiln, crushed and ground in cyanide solution, without any preliminary treatment.

Results:

Test No.		Assays	
	Heads	Tails	Ext.
1	.203	.048	76.4
2	.202	.061	69.6
3	.20	.067	66.5

1936-10-11
FLOTATION-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Purpose of Investigation:

A follow up on preliminary flotation work done in 1935 on ore from the transition zone.

Procedure:

Test No.	Flotation Practice	Grind	Time Min.	Reagents
1	Cyanidation of tails	80	10	Z-5
2	Float arsenic but no gold; cyanide tails	80	8	CA
3	Cyanide flotation tails	80	5	Z-5
4	Float only arsenic; cyanide tails	100	5	CA
6	Sulfide float; cyanide tails	100	17	Z-5;#15
7	Float arsenic; cyanide tails	200	4	CA
8	Sulfide float; cyanide tails	200	17	Z-5
11	Arsenic float; cyanide tails	20	5	CA
12	Arsenic float; cyanide tails	35	5	CA

Results:

Test		Assays Oz Au/ton				
		Flotation			Cyanidation	
No.	Heads	Conc.	Tails	Rec.	Tails	Ext.
1	.22	.68	.20	15.0	.08	63.2
2	.22	.32	.21	7.5	.105	52.7
3	.22	.43	.21	8.5	.11	47.9
4	.22	.27	.22	6.6	.08	63.8
6	.212	.58	.19	33.3	.05	72.4
7	.215	.39	.205	9.35	.087	59.3
8	.229	.63	.165	37.8	.042	75.2
11	.228	.34	.224	5.1	.062	72.8
12	.223	.25	.222	5.1	.055	75.3

Summary:

1. Some 40 to 50% of gold is refractory to direct cyanidation even when ground to minus 200 mesh.

2. Virtually all of the realgar and orpiment can be removed by flotation, in a minus 20 mesh feed without removing more than 5% of the total gold.

3. Straight flotation with a minus 200 mesh grind recovers 40% of the gold in a low grade concentrate.

4. Flotation recovers a gold refractory to cyanidation. An overall recovery of 85% can be made by flotation and direct cyanidation of the flotation tailing.

5. Flotation of arsenic; roasting; cyanidation yields a net extraction (deducting gold in arsenic concentrate) of 70%.

1937-2
FLOTATION-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure:

Test No.	Flotation Practice	Grind	Time	Reagents
15	To raise sulfide concentrate grade	200	18"	Z-5
15d	Cyanidation of flotation tailings from #15		48'	1.5#NaCN
15e	Flotation tails cyanided with Bromo-NaCN		96'	
17d	" " "		48'	1.5#NaCN
17e	" " "		96'	
19	Sulfide flotation; cyanide tails	200	18"	Z-5
19a	Flotation tails cyanided with Bromo-NaCN		48'	
20	Sulfide flotation; cyanide tails	200	18"	Z-5 Na_2CO_3

Results:

Assays Oz Au/ton

Test		Flotation			Cyanidation	
No.	Heads	Conc.	Tails	%Rec.	Tails	%Ext.
15-15d	.224	1.04	.165		.06	64.9
15e			.17		.045	74.3
17d			.17		.05	72.0
17e			.17		.05	72.0
19	.231	.65	.155	43.2	.055	64.3
19a			.155		.05	68.4
20	.219	.42	.155	44.0	.05	71.3

1937-3-1 and 2

Purpose of Investigation:

To compare flotation results of different ore samples.

Procedure:

A sulfide float was made after a 200 mesh grind. Flotation time was 17 minutes with Z-5 as the promoter reagent. Flotation tailings were cyanided with a 2.0 lb. NaCN Solution.

Results:

Assays Oz Au/ton

Test		Flotation			Cyanidation	
No.	Heads	Conc.	Tails	%Rec.	Tails	%Ext.
1	.649	2.08	.40	48.3	.135	68.9
4	.366	.94	.24	46.2	.125	50.0
5	.602	1.62	.41	42.8	.13	69.1
6	.592	1.52	.41	42.2	.14	66.7
7	.611	1.62	.39	47.6	.13	69.3
8	.590	1.60	.38	46.7	.15	64.9

1937-3-1 and 2
FLOTATION-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Summary:

Different ore samples have consistently given different results. The final residue from direct cyanidation of the flotation tails is about the same as the residue from cyanidation of the calcine.

1937-4

Purpose of Investigation:

To investigate pretreatment of the ore prior to flotation.

Procedure:

Test No.	Pretreatment	Size	Time Min.	Reagents
19	wash the ore; float slimes	1/4"	10	Z-5; #31
20	" " " " "	1/2"	10	Z-5; #31
21	H_2SO_4 5% acid treatment ahead of flotation	100	10	Z-5; #31
22	HCl 5% " " " " "	100	10	Z-5; #31

Results:

Test	Slime	Gold	Flotation				Cyanidation	
No.	% Wt.	%Dist.	Heads	Conc.	Tails	Rec.	Tails	Ext.
19	17.2	25.5	.52	1.98	.59	9.0		
20	13.9	22.6	.50	2.15	.61	9.0		
21			.50	2.20	.285	49.3	.12	58.0
22			.56	1.56	.30	56.9	.095	68.0

Summary:

The results are the same as without acid treatment.

1937-10

Purpose of Investigation:

To try the flotation scheme that was so successful on a similar ore at Mercur, Utah.

1937-10
FLOTATION-CYANIDATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Procedure:

Part of the xanthate was added to the grinding circuit, the pulp conditioned with copper sulfate followed by soda ash addition to a pH of 8.0.

Test No. 122: Z-6 was used in a 200 mesh grind. Flotation was for 18 minutes at 22% solids. The flotation tailing was cyanided for 48 hours with a 2.0 lb. NaCN solution.

Results:

Assays Oz Au/ton

Heads	Conc.	Tails	%Rec.	Tails	%Ext.
0.55	1.28	.39	38.4	.175	54.9

No improvement over other results.

1937-2
MISCELLANEOUS-CYANIDATION, DIRECT
U. S. Bureau of Mines - Leaver, Woolf, Jackson

Purpose of Investigation:
To determine if grinding the ore to minus 300 mesh would aid extraction.

Procedure: Tests #13-14
The ore was ground to minus 300 mesh and cyanided 96 hours at 4:1 dilution with a 1.0 Lb. NaCN solution. Cyanide consumption was over 4.0 lbs. per ton and lime consumption approximately 16.0 pounds.

Results:
A 0.2302 head gave a 0.09 residue for a 60.0% extraction.

Purpose of Investigation:
To determine effect of pretreating the ore prior to cyanidation.

Procedure and Results:
A minus 20 mesh ore was cyanided for 48 hours at a 4:1 dilution with a 2.0 lb. NaCN solution.

Test		Results		
		Assays Oz Au/ton		
No.	Pretreatment	Heads	Tails	%Ext.
71	Direct cyanidation-solution very foul	.53	.27	48.3
76	Direct cyanidation-solution very foul	.515	.27	47.6
77	H_2SO_4 2% - 6 days acid treatment	.515	.27	47.6
77b	Same acid treatment followed by 100 mesh grind	.55	.275	50.0
72	HNO_3 in place sulfuric acid treatment no benefit		Not effective	

Purpose of Investigation: #76a
To cyanide the ore directly; float the arsenic and regrind and recyanide.

Procedure:
The ore was cyanided at 20 mesh at a dilution of 3:1. Solutions were very foul with a cyanide consumption of 10 lbs. NaCN. The cyanide residue was floated at 20 mesh to remove the arsenic minerals. The flotation tailings were ground to minus 100 mesh and refloated to recover the gold, activating with Na_2CO_3 and $CuSO_4$.

Results:

Assays Oz Au/ton			Re-cyanidation
Heads	Tails	%Ext.	%Ext.
.515	.27	46.6	56.6

Summary:
This method of treatment is definitely out because of high cyanide consumption and low gold recovery.

1937-2
MISCELLANEOUS-GRAVITY CONCENTRATION
U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Purpose and Procedure of Investigation:

To determine if some of the gold could be concentrated by gravity. A cyanide residue from a 200 mesh grind was carefully panned. One small thin piece of gold was seen under the microscope.

Results:

	Assays Oz Au/ton		
Heads	Pan Conc.	Tails	%Rec.
0.13	0.876	0.12	1.8

Summary:

These results indicate there is little chance of effecting any concentration of the gold in the cyanide residue.

1936-11
MINERALOGICAL DATA
U. S. BUREAU of MINES - Head

Purpose of Investigation:

To obtain information on how the insoluble portion of the gold is associated with the other constituents of the ore. Roasting tends to liberate some of the gold, but also tends to lock up gold as an insoluble complex in such a manner that it remains insoluble in cyanide.

Microscopic Examination:

Portions of ore crushed to minus 20 mesh, as well as coarser sizes, were examined in various ways under a microscope. This included examination of concentrated portions, before and after treatment with acid.

The following minerals were identified: Realgar, orpiment, pyrite and arsenopyrite. There is a possibility that pyrrhotite and marcasite are present in very small amounts, but the identification of these two minerals is not definite. No free gold was detected in any part of the microscopic examination, which indicates that the gold is extremely, finely divided, and possibly disseminated through all the minerals.

To determine how much of the gold is held in the siliceous portion of the ore, a number of aqua regia dissolution tests were made. The treatment with aqua regia, as applied in the following tests, is drastic enough to dissolve all of the constituents of the ore except silica and carbon. Therefore, the residue from the treatment with aqua regia would contain only that portion of the gold encased in the silica and in any carbonaceous material.

Aqua Regia Test No. 1

This test was made on original ore ground to 98% minus 100 mesh. The residue from this test assayed 0.0175 ounce gold per ton from a 0.220 head.

Aqua Regia Test No. 2

On a cyanide tailing from which realgar and orpiment had been removed by flotation. Residue assay 0.0125 oz. Au/ton.

Aqua Regia Test No. 3

Flotation-cyanidation residue after aqua regia treatment assayed .0075 oz. Au/ton.

Aqua Regia Test No. 4

Heads had been floated to remove realgar and orpiment, then roasted and the calcine treated by cyanidation. Head assay 0.04 - Aqua regia tailing 0.01.

Chemical analysis of the ore:

SiO_2 - - - - - -	71.05%
Fe - - - - - -	4.68
Sb - - - - - -	Nil
Au - - - - - -	0.6302 Au/ton
Al_2O_3- - - - - -	9.28
CaO - - - - - -	2.14
As - - - - - -	2.36
S - - - - - -	2.71
Unaccounted for	7.33
Total	100.00

1936-11
MINERALOGICAL DATA
U. S. BUREAU of MINES - Head

Summary:

In general, the results of the aqua regia tests show that if all of the gold not incased in siliceous material or carbonaceous matter could be recovered then a fairly high extraction would be made. Also, a lower aqua regia residue is obtained on material, previously treated by flotation and cyanidation than is obtained on original feed. This indicates that some of the small amount of gold recovered in the flotation concentrate is apparently not dissolved by the aqua regia treatment. Test No. 4 above shows further that the roasting treatment has locked up some of the gold in a manner such that it is not soluble in cyanide but is soluble in aqua regia.

The net results of the microscopic examination and of the aqua regia tests, from the practical standpoint, show that less than 10% of the gold is locked in the silica or in any other way so that it resists dissolution with aqua regia. It appears then that if the gold could be released from the sulfides or their alteration products by extremely fine grinding, or by roasting in such a way as to liberate the gold without forming insoluble gold complexes, an extraction of about 90% should be economically attainable. The following tests have been made, keeping in mind the results and tentative conclusions of the aqua regia tests.

1937-3
U. S. BUREAU of MINES - Head, Oldright, Zimmerley

Purpose of Investigation:

To examine a residue obtained from a 710°C roast of a 10 mesh feed. The calcine was leached with sulfuric acid for 24 hours; washed; ground to minus 100 mesh and cyanided. Heads 0.66 oz. Tails 0.06 oz. Ext. 90.9%

In summing up the results of microscopic examination of the Getchell ore and tailings, the facts seem to be as follows:

(1) The greater portion of the gold occurs as metallic particles that are coated or obscured to the extent that they are not recognizable in a panned concentrate. The majority of these particles, however, are soluble in cyanide since but five free gold particles were observed in a tailing panned from the residue after 46 hours cyanidation. It is evident that these particles, which were tarnished to a dark copper color, are refractory to cyanide under the conditions of the treatment given.

(2) Since no additional gold was found after dissolving oxide iron particles with $HCl + SnCl_2$, it appears that gold bearing pyrite particles, after roasting may yield their gold to cyanide.

(3) Since additional gold particles were found in the concentrate panned from the tailings after the pyrite had been roasted and treated with $HCl + SnCl_2$, it is known that it is necessary to roast completely all the pyrite in the Getchell ore to insure that cyanide comes into contact with the gold particles and dissolves them.

(4) The finding of free gold particles in the cyanide residue indicates that some gold has actually been liberated by the mechanism of roasting and also evidences the fact that the contact of gold particles with cyanide solution does not insure their dissolution.

1937-2-4

CYANIDATION-FLOTATION CONCENTRATES

U. S. BUREAU of MINES - Leaver, Woolf, Jackson

Purpose of Investigation:

To roast and cyanide flotation products.

Procedure and Results:

Test No.	Product Treated	Roasting Conditions			Results Assays Oz Au/ton		
		Size	Time Min.	Temp. °C	Heads	Tails	Ext.
18a	Flotation cleaner tailing	200	90	620	.27	.05	81.3
18b	Flotation cleaner Concentrate	200	120	770	.806	.10	87.6
20c	Flotation Rougher Concentrate	200	90	670	.47	.08	82.4
9	1937-4 Flotation Concentrate	200	90	720	1.98	.32	83.8

Summary:

This recovery seems to be the maximum by flotation, cyanidation of flotation tailing, and roasting-cyanidation of flotation concentrates.

The concentrate calcine is as refractory as the ore.

1937-3
ROASTING-CYANIDATION
THE DORR COMPANY - Darby

Purpose of Investigation:
To develop a method of recovering the gold from Getchell sulfide ores.

Purpose and Results:
In all tests the roaster charge was rabbled every five minutes. The calcine was ground to minus 200 mesh and cyanided for 72 hours at a 2:1 dilution with 3 lb. NaCN solution.

		Roasting Conditions			Results		
Test			Time	Temp.	Assays	Oz Au/ton	
No.	Pretreatment	Size	Min.	°C	Heads	Tails	%Ext.
25	NaOH 5 lbs. 1 ton during grinding	10	60	400	.349	.075	78.5
26	Same	10	120	400	.349	.07	80.0
27	Same	10	120	400	.349	.08	77.2
29	Same	10	60	600	.355	.078	77.7
30	Same	10	120	600	.355	.078	77.7
49	Same	35	60	800	.366	.155	57.7
50	Non-oxidizing roast	35	60	650	.355	.12	66.2
51	Same	35	60	400	.346	.078	77.5
52	NaOH in grind follow by washing	35	60	600	.353	.088	75.1
53	Same	35	60	600	.353	.08	77.4
54	H_2SO_4 10 lbs. p.t.o. - washed	35	60	400	.346	.08	76.9
60	Strong NaCN 7 lbs. p.t.o.	35	60	600	.353	.08	77.4

Summary:
On direct cyanidation of the ore the oxides give 87% extraction whereas the sulfides give 15.8%. Roasting at 400°C to 600°C followed by water wash and cyanidation for 72 hours gave an 0.08 ounce tailing. Roasting increased extraction about 60% plus.

1937-7

Purpose of Investigation:
To make a good extraction by roasting without special treatment.

Procedure and Results:
Same technique as in previous tests.

Test			Time	Temp	Assays	Oz Au/ton	
No.	Conditions	Size	Min.	°C	Heads	Tails	%Ext.
78	Low temperature roast	10	120	300	.20	.15	25.0
82	Roasted at 400°C;floated-cyan.	10	60	400	.18	.065	64.0
83	No roast; pre lime treatment				.18	.17	5.6
86	Slow temperature rise	10	180	540	.335	.045	87.4
87	No roast - Bromo NaCN				.18	.15	16.7

Screen analysis of calcine residue.

	%Wt.	Oz. Au/ton	% Au. Dist.
Plus 200	5.7	.115	9.9
200/325	20.0	.09	27.2
325/43 microns	8.0	.105	12.7
-43 microns	66.3	.05	50.2

Summary:

There is very little increased extraction to be gained by finer grinding. It appears that some other means is necessary to unlock the gold to make it available for cyanidation. Roasting does this to a large extent but not completely. The best roasting results were obtained from a slowly increasing roasting temperature to 540°C in two hours.

1937-3
FLOTATION-CYANIDATION
THE DORR COMPANY - Derby, Rawlings

Purpose of Investigation:

To determine amenability to flotation. Flotation heads assayed 0.19 ounces of Au/ton.

Procedure and Results:

Test No.	Conditions	Grind	Reagents	Conc. % Wt.	Results Assays Oz Au/ton Conc.	Tails	% Ext.
1	General Flotation	100	H_2SO_4-Z5	8.34	.65	.145	29.0
2	" "	200	Na_2CO_3-Z5	8.48	.40	.16	20.0
3	" "	200	NaOH-$CuSO_4$-Z5	25.2	.47	.12	57.0

1937-7

84	Sulfide Flotation	100	Na_2CO_3-Z5		.275	.19	3.6
85	Tails #84 roasted 60 min. 600°C; cyanided					.05	74.4
86	Sulfide flotation					.17	12.8

Summary:

A good arsenic recovery was made but a very poor gold recovery.

1937-6
ROASTING-OF SIDERITE R
THE MERRILL COMPANY - Tyler

Purpose of Investigation:

To determine the gold extraction on calcines at different temperature roasts.

Procedure and Results:

The minus 100 mesh calcines were cyanided at a 2:1 dilution with a 1.0 lb. NaCN solution.

Test No.		Temp. °F	Agit. Time	Assays Heads	Results Oz Au/ton Tails	Ext.
1	Cyanidation of calcines	1000	18	.572	.115	81.17
2	" " "	1000	42	.574	.10	82.76
3	" " "	1200	18	.564	.093	83.40
4	" " "	1200	42	.559	.09	83.93
5	" " "	1500	18	.542	.12	78.73
6	" " "	1500	42	.551	.11	80.83
7	" " "	1000	18	.581	.115	81.17
8	" " "	1000	18	.575	.115	81.17
12	" " "	1200	18	.532	.07	87.5
13	10m reroast - 1% NaCl	1200	18	.531	.11	79.63

1937-7

Purpose of Investigation:

To determine the effects of pretreatment of the calcines.

Procedure and Results:

After a roast at 1500°F the calcines were ground dry to minus 100 mesh and cyanided at a 2:1 dilution for 18 hours with a 1.0 lb. NaCN solution.

Test No.	Pretreatment of Calcines	Assays Heads	Results Oz. Au/ton Tails	Ext.
14	Water agitation with air for 30 minutes	.56	.083	85.2
15	" " " 10 lbs. CaO for 30 minutes	.556	.093	83.4
16	Na_2CO_3 5% agitation at 200°F for 30 minutes	.553	.07	87.5
17	" 2% " " 107°F for 5 hours	.551	.085	84.8
18	Water agitation-hot for 3 1/2 hours	.537	.096	83.0
19	Aqua Regia-boiled for 1 hour	.56	.04	93.0
21	Na_2CO_3 5% heated 190°F for 4 hours	.562	.085	84.8
22	Flotation of calcine with Pine Oil	.56	.557	3.27
23	Cyanidation of flotation tailing	.53	.10	82.0
24	" " " "	.52	.10	82.0
25	400m grind 4 hrs. preaeration	.558	.09	83.8
26	Same but preaeration in lime water	.555	.09	83.8
27	400m 24 hr. agitation in sat. SO_2 solution	.55	.125	77.3
28	H_2SO_4 20#/ton - 4 hrs. agitation at 120°F	.544	.055	90.2

Procedure and Results: (continued)

Test No.	Pretreatment of Calcines	Results Assays Oz. Au/ton Heads	Tails	% Ext.
	An 81% - 200 mesh grind followed by cyanidation at 2:1 dilution with a 2.0 lb. NaCN solution and 10.0 lbs. CaO			
29	2 hour cyanidation	.535	.105	80.5
30	4 " "	.535	.105	80.5
31	8 " "	.535	.10	81.3
32	24 " "	.545	.12	78.0
33	Aqua regia treatment	.56	.02	96.4

Test No.	Pre-treatment	Roast Temp. °F.	Final Grind	Treatment Hrs. Time	Temp. °F.
34	H_2SO_4 2% Na_2CO_3 - 40 lbs. 1 ton 18 hrs.	1500	200	5	120
35	" 1% " " " " " " "	1500	200	18	120
36	" 2% " " " " " " "	1000	200	5	180
37	" 1% " " " " " " "	1000	200	1	180
38	Direct cyanidation for 20 hours	1000	200		
39	Na_2CO_3 20# P.T.C. cyanided with Na_2CO_3 20#	1000	100	1	120
40	" 34 lbs. agitation with 2# NaCN	1000	100		150
41	" 34 lbs. " " 4# NaCN	1000	100		Room

Results:

Test No.	Results Assays Oz Au/ton Heads	Tails	% Ext.
34	.551	.08	85.5
35	.546	.09	83.5
36	.54	.078	85.6
37	.54	.07	87.2
38	.543	.08	85.5
39	.556	.06	89.2
40	.568	.045	92.1
41	.569	.08	86.0

1937-9

Purpose of Investigation:

To find out if there was a difference in extraction between air cooled and quenched calcines.

1937-9
ROASTING-CYANIDATION
THE MERRILL COMPANY - Ryler

Procedure and Results:

The calcines were taken directly from the kiln and quenched in a 10 lb. Trona solution. The calcines were ground to 85% minus 100 mesh and cyanided with a 3.0 lb. NaCN solution for 19 hours.

Test No.	Pretreatment	Roast °F	Results Assays Oz Au/ton Heads	Tails	%Ext.
45	Quenched; ground; cyanided	1000	.69	.065	90.5
46	Air cooled; " "	1000	.54	.055	89.9
47	Quenched; " "	1250	.56	.055	90.1
48	Air cooled; " "	1250	.585	.06	89.8

1938-5

Purpose of Investigation:

To pretreat Getchell Plant roasted calcines and determine which treatment gives the best gold extraction.

Procedure and Results:

The calcines were ground to minus 200 mesh, after being pretreated, and cyanided with a 2 lb. NaCN solution.

Test No.	Pretreatment	Results Assays Oz Au/ton Heads	Tails	%Ext.
52	Water leach - 112°F for 20 hrs.	.224	.04	82.2
53	Water leach with milk of lime 20 hrs.	.235	.05	78.7
54	Trona leach 10# 1 ton for 20 hrs.	.23	.05	78.3
55	Water leach - cold " " "	.22	.07	68.2
56	H_2SO_4 2% leach at 1:1 for 18 hrs.	.226	.08	64.6

1939-1

Purpose of Investigation:

A Getchell Plant Kiln composite sample gave the following results.

Results:	% Wt.	Assays Oz Au/ton	Gold Dist.%
Mesh analysis Plus 6	52.5	0.22	11.5
Mesh analysis Minus 6	47.5	0.39	18.5
			30.0

#1 - Kiln discharge ground to 90% minus 200 mesh and cyanided 24 hours.
#2 - Kiln discharge re-roasted one hour at 1050°F (ground to 90% minus 200 mesh and cyanided 24 hours).

	#1 %Ext.	#2 %Ext.
Plus 6 mesh	84.4	89.2
Minus 6 mesh	79.8	86.1
	81.2	87.7

1938-5
ROASTING-CYANIDATION
GETCHELL MINE - Wark, Woodward

Purpose of Investigation: #1

To determine if the Plant Roast was more effective on finer sizes than on coarse sizes.

Procedure:

Several daily kiln discharge samples were divided into plus 3/8" and minus 3/8" sizes. Each portion was ground to minus 200 mesh and cyanided 48 hours.

Results:

	+3/8"	-3/8"	+3/8"	-3/8"	+3/8"	-3/8"	+3/8"	-3/8"
Heads	.165	.18	.155	.135	.120	.130	.145	.13
Tails	.05	.045	.055	.085	.05	.055	.055	.06
Extraction%	69.7	75.0	67.8	37.0	58.3	57.7	64.2	60.0

Procedure: #2

Each sample was separated into +65 mesh and -65 mesh material; ground to minus 200 mesh and cyanided.

Results:

	+65 Mesh	-65 Mesh	+65 Mesh	-65 Mesh
Heads	.12	.15	.10	.09
Tails	.06	.045	.05	.07
Extraction %	50.0	69.9	50.0	22.3

Procedure: #3

Weekly composite samples were separated into +65 mesh and -65 mesh; ground to 90% minus 200 mesh; washed 24 hours and cyanided 40 hours.

Results:

	+65	-65	+65	-65	+65	-65
Heads	.24	.19	.31	.30	.23	.185
Tails	.07	.135	.10	.135	.07	.085
Extraction%	70.5	28.9	67.9	55.0	69.5	54.0

Purpose of Investigation: #4

Screen sizing of Plant tailing of different samples

Results:

Mesh Size	% Wt.	Assay Oz/ton	% Wt.	Assay Oz/ton	% Wt.	Assay Oz/ton	% Wt.	Assay Oz/ton
65	2.0	.07	3.0	.17	2.0	.07	3.0	.12
65/100	8.0	.07	8.0	.10	8.0	.06	9.0	.07
100/200	63.0	.07	57.0	.06	51.0	.06	41.0	.07
200/325	21.0	.07	39.0	.07	35.0	.09	36.0	.08
-325	6.0	.08	3.0	.10	4.0	.11	11.0	.09
Total		.07		.078		.073		

1938-7
ROASTING-CYANIDATION
GETCHELL MINE - Mark, Woodward

Purpose of Investigation:

To determine the effect of calcine pretreated ahead of cyanidation.

Procedure and Results:

A ten day composite sample of Kiln discharge was ground to minus 200 mesh; diluted to 4:1 and boiled on hot plate for one hour, filtered and washed. The sample was split into four portions and treated as follows:

Test		Results		
		Assays Oz/Au/ton		
No.	Pretreatment	Heads	Tails	Ext.
1	Cyanided direct 48 hrs. with 1#/T NaCN solution	.232	.07	70.0
2	H_2SO_4 agitation with 2% sol. ahead of cyanidation	.171	.04	76.6
3	Sodium triphosphate ahead of cyanidation	.208	.07	66.4
4	Trona leach 24 hours " " "	.177	.07	60.5

Procedure:

After a minus 100 mesh grind a kiln discharge was treated with a 10% solution of H_2SO_4; a second sample with 5% NaOH solution, then cyanided for 48 hours.

Results:

	Treatment		Treatment	
	H_2SO_4	NaOH	H_2SO_4	NaOH
Heads	.15	.15	.15	.15
Tails	.115	.11	.08	.085
Extraction %	26.4	26.6	39.5	38.5

1939-3

Purpose of Investigation:

Kiln discharge roasting tests, followed by cyanidation.

Procedure and Results:

Test		Results		
		Assays Oz Au/ton		
No.	Conditions	Heads	Tails	Ext.
1	Roasted 1 hour at 1000°F hot directly from plant	.143	.055	61.5
2	Cooled over night; roasted 1 hour at 1000°F	.151	.055	63.5
3	Cooled; no roast	.155	.055	66.2
4	Roasted 3 hours at 1000°F	.672	.185	74.8
5	" " " " " with 1#/T KCl	.71	.14	80.3
6.	" " " " " with 1#/T Soda Ash	.677	.165	75.5

1942
ROASTING-CYANIDATION
GETCHELL MINE - The Getchell Mine tests which are reported without giving the name of the Metallurgist, were not signed, and may have been made by L. Mills; T. Crow; C. Wark, Sr., C. Wark, Jr.; J. Woodward or others.

Purpose of Investigation:

To compare the effect of gold recovery on a calcine which has been ground ahead of roasting and on grinding a calcine after roasting.

Procedure:

A monthly composite of kiln feed samples was crushed to various sizes and roasted in charges 1/2" deep for two hours at 700°C. Pulps were cyanided for 72 hours.

Results:

Test No.	Treatment Preroast Grind	Postroast Grind	Total % S	SO_4 % S	Assays Oz Au/ton Heads	Tails	% Ext.
1	4	65	.37	.28	.281	.06	85
7	10	65	.42	.32	.283	.078	79
1	4	65	.37	.28	.281	.06	85
5	4	200	.40	.30	.296	.066	88
6	4	325	.40	.28	.268	.039	88
7	10	65	.42	.32	.283	.078	79
8	10	200	.43	.30	.277	.062	83
0	4	65	.96	.11	.267	.075	74
1	4	65	.37	.28	.281	.06	85
2	4	65	.38	.32	.291	.065	87
3	4	65	.82	.07	.295	.075	85
0	4	65	.96	.11	.267	.075	74
4	100	325	.09	.028	.245	.20	17
9	100	100	.58	.63	.28	.073	80

Summary:

A roaster feed finer than 1/4" definitely lowers gold recovery unless the calcine is ground finer than 200 mesh. An extremely fine grind on a 1/4" calcine aids gold recovery.

1940-4
ROASTING—CYANIDATION
GETCHELL MINE - Wark, Woodward

Purpose of Investigation:

To analyze different sizes of kiln discharge.

Procedure:

Kiln discharge samples for 20 days were composited into 9 periods. Mud pellets were separated from each size. Part of the general composite was crushed to minus 4 mesh and re-roasted for four hours at 650°F. Each sample was ground to minus 65 mesh; washed and thickened duplicating plant practice, and then cyanided for 48 hours.

Results:

20 Day Periods	Plus 1/2" 34.0%	-1/2"+3/8" 16.0%	-3/8"+10m 33.0%	-10m 16.5%	Pellets 5.2%	Composite	Reroast Composite
1-Heads	.26	.23	.26	.27	.32		.27
Tails	.07	.075	.075	.11	.11		.045
2-Heads	.20	.18	.21	.24	.23	.22	.22
Tails	.06	.07	.08	.08	.08	.08	.05
3-Heads	.355	.375	.315	.31	.27	.328	.328
Tails	.085	.11	.095	.11	.10	.09	.075
4-Heads	.24	.27	.24	.30	.335	.24	.24
Tails	.069	.072	.077	.108	.11	.07	.097
Trona treatment - ground in hot trona sol. 14 hours agitation							
5-Heads	.235	.23	.22	.23		.22	.22
Tails	.071	.082	.082	.102	.10		
6-Heads	.20	.227	.227	.297	.363		.26
Tails	.06	.07	.07	.14	.15		.05
7-Heads	.26	.26	.26	.29			.255
Tails	.08	.08	.11	.135			.05
8-Heads	.21	.21	.20	.22			.20
Tails	.075	.095	.08	.09			
Average Heads	.232	.250	.245	.275	.297	.263	.253
" Tails	.071	.082	.084	.11	.10	.079	.051

Summary:

Extraction on the above assays:

1	73.0	68.0	71.0	59.0	66.0	83.0
2	70.0	61.0	62.0	67.0	65.0	78.0
3	77.0	71.0	70.0	65.0	63.0	77.0
4	77.0	73.0	68.0	64.0	67.0	76.0
5	75.0	72.0	70.0	67.0	66.0	70.0
6	70.0	69.0	60.0	53.0	59.0	81.0
7	69.0	69.0	58.0	54.0		78.0
8	64.0	55.0	60.0	59.0		75.0
Average	71.8	67.3	64.9	61.3	64.3	77.2

1940-4
ROASTING-CYANIDATION
GETCHELL MINE - Wark, Woodward

Summary: (continued)

The total sulfur in the composite sample averaged approximately 1.0%, the sulfate sulfur approximately 0.15%. After re-roasting the average sulfur was 0.4% with the sulfate sulfur 0.3%.

These results show that the roast is incomplete, especially on the finer portions of the ore. In practice we have found that if more heat is applied the ore fuses and sticks to the kiln lining.

Fusion starts from 1500° to 1600°F which is 400° to 500° above the rock temperature.

1940-6

Purpose of Investigation:

Resume' of sulfur and arsenic elimination in ten day period composite samples for six months.

Resume'

10 day Periods	Total Feed	Sulfur Disch.	%	Total Feed	Arsenic Disch.	%	Heads	Plant Tails	Bottle Tails	Extraction Plant	Extraction Bottle
1	2.60	1.11	57.3	1.67	.19	88.5	.202	.05	.053	75.3	73.8
2	2.08	.94	54.8	1.53	.24	84.4	.215	.048	.05	77.7	76.8
3	2.02	.96	52.5	1.00	.20	80.0	.395		.06		84.8
4	2.24	.97	56.7	2.19	.26	88.2	.204		.055		73.1
5.	1.75	.91	48.0	1.02	.22	78.4	.222		.056		74.8
6	1.50	.69	54.0	.93	.15	83.9	.239		.064		73.2
7	1.67	.70	53.9	1.03	.16	84.4	.216	.05	.052	76.8	75.9
8	2.03	1.06	47.8	.85	.10	88.2	.231	.063	.066	72.8	71.5
9	1.70	1.01	40.6	.73	.14	80.8	.289	.082	.081	70.6	72.0
10	1.40	.85	49.3	.56	.21	62.5	.256	.068	.065	73.4	74.6
11	2.06	1.31	36.4	.76	.19	75.0	.244	.078	.074	68.0	69.7
12	1.97	1.21	38.6	.77	.27	64.9	.246	.071	.068	71.1	72.3
13	1.98	1.14	42.4	.81	.19	76.6	.173	.055	.054	68.3	68.8
14	2.48	1.58	36.3	1.07	.30	71.9	.293	.074	.085	74.8	71.1
15	2.67	1.65	38.2	.68	.18	73.5	.338	.117	.133	65.4	60.7
16	3.52	1.91	45.8	1.21	.21	82.6	.473	.132	.136	72.1	71.2
17	2.74	1.55	47.1	1.01	.17	83.1	.287	.096	.096	67.5	66.6
			47.2			80.0					

1940-6 (2)
ROASTING-CYANIDATION
GETCHELL MINE

Purpose of Investigation:

To determine the effects of roasting a Getchell calcine at different sizes for different lengths of time.

Procedure:

The sample was a composite of calcines produced over a two months period.

Results:

	Roasting Conditions			Results		
				Assays Oz Au/ton		
Hours Time	Mesh Size	Temp°F	Final Grind	Heads	Tails	%Ext.
0	4	1300	65	.287	.075	72.0
2	4	1300	65	.280	.06	79.0
2	4	1300	200	.266	.036	86.5
2	4	1300	325	.268	.039	85.5
4	4	1300	65	.261	.035	86.5
6	4	1300	65	.265	.045	83.0
2	10	1300	65	.275	.07	74.5
2	10	1300	200	.275	.06	78.0
4	100	1300	100	.277	.07	75.0
6	100	1600	325	.265	.22	17.0

Conclusions:

1. Re-roasting improves the extraction if the temperature is not carried too high. A temperature higher than 1300°F fuses the ore and "locks up" the gold.

2. Finer grinding after roasting improves the results.

3. Grinding finer than 4 mesh before roasting lowers the extraction.

4. A re-roasting period of more than two hours seems to be of little benefit.

1940-8
ROASTING-CYANIDATION
GETCHELL MINE

Purpose of Investigation: #1

To determine effect of ore size of roaster feed on cyanidation results.

Procedure:

Composites of six days of kiln feed samples were split into two portions. One was roasted direct, the other crushed to minus 4 mesh and roasted. Roasting was as follows: Cold to 600° in 105 min.; 600° to 800° in 45 min.; 800° to 1050° in 45 min.; 1050° to 1300° in 45 minutes. The calcines were cooled, quenched, ground to minus 65 mesh and washed by decantation. Cyanidation was for 48 hours.

Results:

6-Day Periods	Total Sulfur Raw Ore Orig.	Total Sulfur Raw Ore -4M	Calcine Orig.	Calcine -4M	Heads Orig.	Heads -4M	Tails Orig.	Tails -4M	Extraction Orig.	Extraction -4M
1	2.0%	2.0%	.4%	.3%	.374	.274	.05	.07	86.0	74.0
2	2.1%	2.1%	.6%	.4%	.31	.296	.06	.06	81.0	80.0
3	2.05%	2.05%	.55%	.48%	.222	.255	.05	.06	76.5	77.5

Procedure: #2

A two week composite sample of kiln feed was separated into the sizes given below. Each size was roasted 0 to 850° in 105 minutes; 850° to 1200° in 45 min. at 1200° in 30 minutes. After grinding to minus 65 mesh the calcines were washed and cyanided.

Product	% Wt.	Sulfur Assays Ore	Sulfur Assays Calcine	Assays Oz Au/ton Heads	Assays Oz Au/ton Tails	Assays Oz Au/ton Ext.
Composite		2.86%	.60%	.285	.09	68.5
+1/2"	20.9	2.91	.79	.305	.105	65.0
+1/2" -4	23.0	2.86	.66	.362	.11	69.0
-4 +10	23.2	2.96	.53	.275	.103	63.0
-10 +20	13.8	2.90	.61	.261	.08	69.4
-20 +100	13.4	3.13	.49	.258	.07	72.0
-100	5.7	2.82	.65	.250	.07	72.0

Summary:

One would expect the extraction to increase as the sulfide sulfur was eliminated as the gold occurs in the sulfide particles, and these particles have to be 'opened up' before the gold can be dissolved by cyanide. This seems to be true with the coarser material but not with the finer material. The sulfide sulfur cannot be the only factor influencing the solubility of the gold as in the -20 +100, and -100 mesh products the sulfide sulfurs is completely eliminated, but the cyanide residues are still high in gold.

Procedure: #3

A two weeks composite sample of kiln feed was separated into sizes and each size roasted 500° to 1300° in 135 minutes and held at 1300°F 30 minutes. After grinding to minus 65 mesh, the pulp was washed and cyanided.

Results:

				Results		
		Sulfur	Sulfur	Assays	Oz Au/ton	
Product	% Wt.	Ore	Calcine	Heads	Tails	%Ext.
Composite	100.0	2.61	.20%	.24	.06	75.0
1/2"	25.1	2.41	.29	.269	.08	70.4
4M	27.6	2.45	.28	.272	.08	70.7
10M	21.4	2.73	.34	.248	.08	67.8
20M	12.1	2.64	.35	.249	.08	68.0
+100	10.4	2.97	.46	.28	.08	71.5
-100						
	3.4	3.18	.75	.314	.08	74.6

Test #4					
Composite		3.08	.37	.173	.06
1/2"	42.8	2.67	.71	.153	.07
4M	20.4	2.76	.42	.195	.09
10M	11.2	3.28	.38	.198	.075
20M	12.2	3.67	.34	.213	.08
+100	9.2	3.71	.38	.194	.05
-100	4.2	3.84	.49	.19	.09

Same samples as Test #2-#3-#4; however, after roasting, the samples were ground to minus 65 mesh in hot trona solution (50#/T at 170°F) before cyanidation.

Tests	2A		3A		4A	
	Tails	%Ext.	Tails	%Ext.	Tails	%Ext.
Composite	.07	72.4	.06	76.3	.06	75.0
+1/2"	.08	71.1	.07	73.7	.05	66.7
+1/4"	.07	76.8	.06	78.5	.06	67.5
+10	.07	71.0	.06	75.0	.06	70.0
+20	.10	63.8	.06	75.0	.07	67.0
+100	.07	72.3	.07	74.3	.06	71.0
-100	.08	68.3	.08	74.7	.07	64.0

Summary:

The results of these tests show;

1. That finer crushing of the kiln feed would be little aid in increasing extraction.

2. Over-all recovery would be increased slightly (2% to 3%) by the use of trona pretreatment in the place of the current water wash.

Summary: (continued)

3. The recovery of gold does not follow the sulfur elimination curve, which means there are other factors influencing the solubility of the gold in the calcine.

4. The Trona pretreatment has a pronounced effect on the +10 mesh material and of little benefit on the -10 mesh material. The trona attacks the sulfur in the calcine.

Purpose of Investigation: #5

To determine the efficiency of a water wash on calcines versus a sulfuric acid wash.

Procedure and Results:

The calcines were ground to minus 65 mesh, washed in water and cyanided 48 hours. The sulfuric acid wash was at a 2:1 dilution - 2% H_2SO_4 solution. Agitation time was 24 hours; after washing the pulp was cyanided 48 hours.

Test	ROASTING	CONDITIONS			WATER TREATMENT			H_2SO_4 TREATMENT		
No.	500°F to	Time	Hold at	Time	Heads	Tails	Ext.	Heads	Tails	Ext.
97	1200	120	1200	60	.231	.06	74.0	.228	.06	73.6
98	1100	60	1200	180	.268	.055	79.5	.254	.05	80.4
99	1400	180	1200	60	.248	.05	79.9	.249	.045	81.9
100	1100	60	1200	180	.255	.06	76.6	.247	.055	77.7
101	1400	180	1400	60	.245	.065	73.5	.255	.06	76.5

Summary:

1. An average of the results of all the tests shows the sulfuric acid treatment gives a slightly higher extraction than the water treatment. For sulfuric 78.0% and for water 76.7%.

2. The ore needs to be heated to about 1100°F before effective roasting begins and the temperature must be raised to at least 1400°F for a short time to obtain optimum recovery. Apparently this higher temperature should not be held for a very long time or the recovery will begin to decline. This may be due to sintering or the formation of insoluble arsenic compounds.

3. The arsenic assays of the calcine or the cyanide residues cannot be tied in with the recovery. They hardly vary from roast to roast.

Purpose of Investigation: #6

To try and determine effects of water, sulfuric acid and trona washes on calcines made at different roasts.

Procedure:

The calcines were (1) ground to minus 65 mesh in water; settled 12 hours and washed by decantation. (2) Ground to minus 65 mesh and digested for 6 hours in hot trona, 50#/T solution. (3) Ground to minus 65 mesh and agitated 24 hours in H_2SO_4 solution. Cyanide treatment was 48 hours.

1940-8
ROASTING-CYANIDATION
GETCHELL MINE

Roasting:

#105 500° to 1200°F 60"; 1200° to 1400°F 50"; hold 1400° 130".

#106 0 to 600°F 30"; 600° to 1200°F 80"; 1300° to 1400°F 80"; 1450° to 1300°F 50 minutes.

#107 0 to 500°F 30"; 500° to 1100°F 80"; 1100° to 1400°F 80"; 1400° to 1250°F 50 minutes.

Results:

Test No.	WATER Assays Oz Au/ton Heads	Tails	%Ext.	TRONA TREATMENT Assays Oz Au/ton Heads	Tails	%Ext.	H_2SO_4 TREATMENT Assays Oz Au/ton Heads	Tails	%Ext.
105	.40	.08	80.0	.389	.065	83.2	.395	.065	83.2
106	.413	.065	84.4	.405	.06	85.2	.405	.055	86.3
107	.366	.06	83.6	.369	.06	85.5	.365	.05	85.5

1941-11

Purpose of Investigation:
To determine if aeration of the calcine after grinding would be of aid in the cyanidation of the ore.

Procedure:
The tests were conducted in a large can using impeller agitation, and aerated by introducing compressed air directly under the impeller.

In the first set of tests the pulp was agitated 8 hours with varying amounts of lime. In the second series one pound p.to. lime was added with time of aeration varied. In the third series no lime was used but the time varied. Cyanidation was for 48 hours.

Series #1

Varying amounts of lime added; time of aeration constant.

Method of Treat. Time Aeration	#CaO Added	Percent Sulfur Heads Total	Sulfide	Solution Total	Sul.	Consumption NaCN	CaO	Assays Oz Au/ton Heads	Tails	%Ext.
None	None	1.53	1.44	.42	.04	2.19	2.93	.235	.078	65.6
8	None	1.49	1.39	.47	.05	1.37	2.60	.237	.084	63.1
8	.5	1.49	1.40	.46	.06	1.31	2.56	.23	.075	67.0
8	1.0	1.49	1.39	.45	.06	1.39	2.72	.238	.075	67.7
8	2.0	1.52	1.41	.48	.07	1.20	2.70	.211	.073	64.6

Results: (continued)

Series #2
Lime constant - aeration time varied.

Method of Treat.		Percent Sulfur								
Time Aeration	#CaO Added	Heads		Solution		Consumption		Assays Oz Au/ton		
		Total	Sulfide	Total	Sul.	NaCN	CaO	Heads	Tails	%Ext.
None	None	1.50	1.43	.58	.10	1.90	5.51	.239	.085	64.4
8	1.0	1.44	1.38	.53	.07	1.50	5.18	.224	.083	62.8
16	1.0	1.43	1.36	.57	.08	1.01	4.94	.209	.078	62.2
24	1.0	1.50	1.43	.57	.08	1.08	5.04	.218	.077	65.0
32	1.0	1.50	1.43	.60	.09	1.00	5.00	.208	.073	63.7

Series #3
No lime - aeration varied.

None	None	1.62	1.53	.72	.21	2.49	5.95	.26	.082	69.3
0	None	1.79	1.70	.62	.11	2.08	6.12	.25	.081	67.3
16	None	1.79	1.68	.63	.10	1.85	4.63	.245	.08	67.4
24	None	1.79	1.61	.62	.09	1.73	5.55	.243	.079	67.4
32	None	1.79	1.65	.61	.09	1.64	5.35	.239	.078	67.4

Summary:

The results show that aeration:

1. Lowers the cyanide consumption
2. Lowers the cyanide residues
3. Increase the loss of gold by dissolution in the water circuit, which more than counter-acts the gold gained by the lower cyanide residue.
4. In all the tests a discrepancy exists between the calculated head for the pulps cyanided without aeration. This difference becomes greater with a longer aeration period and cannot be accounted for by the Au content in solution.

1941
ROASTING -CYANIDATION; PLANT PRACTICE
GETCHELL MINE - Wise

MILLING PRACTICE

In the sulfide ores the gold occurs in microscopic sizes, both in the free state and locked up in minute pyrite and arsenopyrite particles. It has been established that the bulk of the free gold is coated with some substance, thought to be an insoluble iron compound. A roast is required prior to treatment in order to secure economic extraction by cyanidation. Roasting accomplishes three things. The insoluble coating on the free gold is converted to a soluble state; the gold bearing fine sulfides are oxidized; and the bulk of the arsenic is eliminated.

Calcined cyanide residues shows micron size gold included in 800 mesh sulfides which, in turn, were included in 300 mesh gangue particles. An ultimate tailing cannot be reached until a dead roast is attained.

After roasting, a wash is required prior to cyanidation. Either hot water, a weak trona solution, or a weak sulfuric acid solution wash is suitable. The wash dissolves the coating from the free gold, removes soluble sulfates and sulfites, ferrous compounds and other cyanides formed during roasting.

Crusher plant product goes to a 700 ton fine ore bin then to a 400 ton roaster feed bin. Roaster feed is 18% + 1/2 inch; 19% + 4 mesh; 63% -4 mesh. The kiln is a 7 1/2 x 260 feet with an inside diameter of 6 feet. It is set on a slope of 3/8 inches per foot and turns 1-1/3 R.P.M. with ore flow of less than one foot per minute. Total time of rock in the kiln is 4 1/2 hours with a 1000°F temperature in the first 200 feet. From that point to the discharge it reaches 1300° to 1400°F. Heating at 1000°F is not sufficient for good gold extraction, and heating above 1400°F, for any length of time is detrimental to extraction. Kiln gases discharge from the feed end at 450°F. Average kiln operating data is;

Rock temperature discharge	1300°F
Sulfur in feed	2.91%
Sulfur in kiln discharge	1.22%
Sulfur elimination	58.1%
Arsenic in feed	2.01%
Arsenic in kiln discharge	0.32%
Arsenic elimination	84.1%
Oil consumption	6.55 gal. per ton.

Roasted ore discharged from the kiln at 1300°F is fed directly to the ball mill scoop box. The grinding unit consists of an 8 x 6 foot ball mill in closed circuit with an 8 x 30 foot multizone classifier. Ball mill discharge is 75% solids at a temperature of 190°F and classifier overflow is 33% solids at 140°F temperature. Grinding and classification are in fresh water, and it is in this unit that a hot water wash is attained.

The classifier overflow of 1.4% plus 65 mesh and 63.7% minus 200 mesh goes to a 55 x 25 foot, three compartment washing thickener. Overflow wash water, containes soluble sulfates, sulfites, iron compounds and small amounts of arsenic. Thickener underflow at 65 to 70% solids went to the slime treatment plant.

Milling Practice; (continued)

Under-flow is agitated in series in two 24 x 20 foot agitators at a dilution of 1.63:1 with cyanide and lime. Overflow goes to a 30 x 18 foot, three compartment tray thickener. Thickener overflow goes to pregnant solution. Underflow at 55 to 60% solids is repulped with barren solution and agitated in three 16 x 16 foot agitators in series.

Secondary agitator circuit overflows to a 45 x 16 foot thickener. Overflow goes to mill solution and underflow goes to a 14 x 14 drum filter.

The arsenic content of the pulp entering cyanide treatment is 0.29%, and in the residues is a 0.28%. The residual arsenic from roasting is not soluble and probably occurs as arsenopyrite. Sulfur entering is 1.29% and in the residues 1.25%. Soluble sulfur occurs as sulpho-cyanides.

1943-9
ROASTING-CYANIDATION
GETCHELL MINE - Wark

Summary:

Numerous laboratory tests which combine roasting the raw ore and treating the roasted product have been conducted, as well as small scale roasting tests, in a small sized rotary kiln. Laboratory tests almost invariably show that if a complete roast is made that the cyanidation results are better than the plant results. Ores roasted in the small kiln also gave a product that treated better than plant roasted ore.

Most of the difference between plant roast and laboratory or experimental kiln roasts, is shown by the better sulfur and arsenic elimination. This difference is due to the fact that in the plant the oxidation of sulfur and arsenic, which is visibly incomplete when the ore leaves the roaster, is immediately stopped by quenching before the grinding operation. In laboratory roasts, the time temperature gradient is kept as close to that of the operating kilns as possible, however, at the finish of roast, instead of quenching as in the plant, the roasted products have been permitted to cool slowly, usually overnight, before sampling for sulfur and arsenic. This could only result in further oxidation if any sulfur and arsenic compounds remained in the ore at the end of the roasting period, and consequently a product that would be more amenable to the following cyanidation.

Transferring the hot ore to a revolving cylinder would retain the ore, with constant stirring or rabbling long enough for the oxidizing reaction to be complete, or until the ore had cooled to a temperature where no further reaction would take place. Cooling should be retarded as much as possible by insulation of the cylinder and proper stirring insured by using "lifter brick" or heat resisting castings as lifters.

Present practice stops all sulfur and arsenic elimination as $SO_2(SO_3)$ and As_2O_3 as soon as the ore leaves the kilns. Some, but not all, of these sulfur and arsenic compounds are dissolved and removed during the grinding and washing operation and are sent to waste. Others find their way into the cyanide circuit and continue dissolving. This causes foul solutions and interferes seriously with the recovery of gold as well as adding to chemical consumption.

From the foregoing, it can be concluded that as far as it goes our present roasting practice is sound but that changes should be made that would permit full advantage to be taken of the heat put into the ore for purposes of oxidizing the sulfur compounds before it is put under treatment by cyanidation.

None of the foregoing has taken into account the addition of chemicals to the grinding circuit for the removal, or dissolution of such compounds as antimony oxides. This is another and a separate problem as is the question of filtration of pulps after washing in thickeners as at present.

1943-9
ROASTING-CYANIDATION
GETCHELL MINE - Humphrey

Purpose of Investigation:

To determine the benefit of roasting the ore in the presence of coal dust and sulfur.

Procedure: Kiln Feed

One set of samples was mixed with 20 lbs/ton of pulverized coal, and one with 20 lbs/ton of sulfur while roasting from 400°F to 1200°F for 2 1/2 hours, and then held at 1200°F for two hours.

The calcines were given a hot NaOH wash for thirty minutes with a one pound solution before cyanidation for 48 hours.

Results:

Consumption

Roast	NaCn	CaO	As	S.	As	S.	Heads	Tails
Coal	1.5	5.4	1.58	2.61	.38	1.30	.18	.025
Coal	1.6	4.5	1.41	2.41	.30	1.17	.16	.025
Sulfur	2.5	5.6	1.58	2.61	.47	.69	.17	.04
Sulfur	2.3	6.0	1.41	2.41	.73	.96	.16	.04

1945-6
GETCHELL MINE - George Crerar

When there is a reducing atmosphere in the roast, as when SO_2 is coming off freely, the As is held in the arsenous oxide (As_2O_3) and passes out with the gasses. When the SO_2 has been eliminated the residual As is oxidized to the arsenic oxide (As_2O_5) which combines readily with iron to form an arsenate which will not yield a gold content to any solvent. Antemony reacts in exactly the same way.

1944-8
ROASTING-CYANIDATION
GETCHELL MINE - McQuiston

SUMMARY:

Extensive research investigations, and a natural metallurgical evalution after six years of milling operations, have brought out several possible flow sheet changes. It is believed that all this data can be incorporated into a redesigned, "streamlined" flow sheet which will give an estimated reduction in milling costs, plus increased gold extraction, of approximately $1.50 per ton of ore.

Redesigning the roasting plant to insure complete sulfide sulfur elimination along with removing the colloidal slimes, will lower the overall cyanidation costs appreciably. Metallurgical gain, by increased gold extraction, should be approximately 0.02 to 0.03 ounces of gold per ton of ore.

The following is a summary of various data and ideas relating to improvement in milling and to the metallurgy of the Getchell ores:

To insure a uniform mill feed the ore from the pit should be bedded prior to milling. The arsenic, antimony, molybdenum, iron and other mineral constituents of the ore varies greatly in concentrations from different sections of the mine. These erratic occurrences of salts and minerals greatly effect metallurgical results, and bedding would do much towards leveling off milling results. Bedding could be accomplished by doing all the mining and truck hauling in the eight weather-favorable months. Practically all crusher plant "wet ore problems" will be eliminated. It has been demonstrated on several occasions that the ore, after being stockpiled for a period of time, presented no difficult crushing problems.

Rebuilding the crushing plant, for a capacity of 250 TPH has been considered under the plant expansion program. It is believed a redesigned and rebuilt plant would give costs less than $0.10 per ton of ore, as compared with the present costs of $0.186.

There is much evidence indicating that washing the primary colloidal slimes from the ore will greatly aid roasting to obtain more complete sulfur elimination from the ore. This fine material causes runs through the roaster, acts as insulation on the coarser particles and creates a severe dusting problem and gold loss. Removing this colloidal material will lower thickening, agitation, filtering and chemical costs. Washing the ore should result in increased gold extraction and lower milling costs approximately $0.50 per ton of ore. It also may possibly permit leaching of a coarse ground calcine; however, laboratory test work is yet to be done along this line.

Several years of plant and laboratory results definitely show that the roaster calcines contain an appreciable amount of sulfide sulfur. Numerous laboratory results from several different laboratories show conclusively that the best gold extraction by cyanidation of the calcines is obtained after the

SUMMARY: (continued)

ore was roasted at 1200°F, and held at or near this temperature for a period of time. In plant practise the ore reaches a temperature of 1200°F and is then immediately quenched in water which stops all oxidation of the sulfides. For the short period of time the ore is at 1200°F it is in a reducing atmosphere instead of an atmosphere favorable to oxidation. It is only necessary to incorporate into the present plant practice a method of holding the calcines at a temperature sufficient to allow oxidation of the sulfides to continue on to completion. The sulfide sulfur remaining in the calcines is not much less than 50% of the sulfide sulfur in the roaster feed. Considerable data shows when oxidation, or roasting, is carried to completion the present gold recovery can be increased 0.02 to 0.03 ounces of gold per ton of ore.

The following is an outline of possible flow sheets, estimates in reducing the present milling cost and increasing the gold extraction. The estimated milling cost, and increased gold extraction is given in dollars per ton of ore.

FLOW SHEET NO. 1:

The present flow sheet of roasting all the ore followed by cyanidation. Installation of subsequent roaster equipment to obtain complete elimination of the sulfide sulfur.

TOTAL INCREASED PROFIT - - - - - $1.00

FLOW SHEET NO. 2:

Includes a washing plant with flotation of the slime portion of the ore. The feed to the crushing plant then becomes 1800 TPD so as to maintain a roaster feed of 1500 TPD.

TOTAL INCREASED PROFIT - - - - - $1.50

FLOW SHEET NO. 3:

Flotation to include fine sands along with the primary slimes for one of two purposes; first, on a 1500 TPD crusher feed this plan might permit roasting and cyanidation of 1200 tons per day, in the present roasters, with only the additional installation of a new crushing plant and two oxidizer tubes; second, if leaching is possible, flotation of the fine sands will produce an ideal leaching product. A flow sheet along this general plan has considerable merit as it involves a low capital cost.

FLOW SHEET NO. 4:

All flotation, with roasting and cyanidation of the flotation concentrates. All flotation producing a small concentrate weight, cyanidation of the flotation tailings, roasting and cyanidation of the flotation concentrates.

FLOW SHEET NO. 5:

Following a four mesh wet grind, float the arsenic, and antimony, from the minus ten mesh product. Slimes to flotation and sands to roast and cyanidation. The merit of this flow sheet is to remove the arsenic to aid roasting or to remove the antimony if the content in the ore is high enough to cause cyanide trouble.

1945
PLANT RESULTS
ROASTING-CYANIDATION
GETCHELL MINE

SULFIDE ORE

(Gold Oz. per Ton)

Year	Heads	Undissolved	Dissolved	Total	Ext.
1938	.198	.0600	.0035	.0635	67.9
1939	.267	.0606	.0031	.0637	76.1
1940	.254	.0652	.0054	.0706	72.2
1941	.211	.0630	.0046	.0676	67.9
1942	.210	.0597	.0050	.0647	69.2
1943	.203	.0652	.0037	.0689	66.1
1944	.198	.0666	.0035	.0701	64.4
1945	.177	.0619	.0033	.0652	63.0

CHEMICAL CONSUMPTION
(Pounds per ton ore)

Year	Cyanide	Lime	Zinc (p.t.Sol)	Lead	NaOH
1943	2.31	8.00	.049	.88	-
1944	2.03	7.34	.047	1.73	1.80
1945	2.07	5.09	.051	2.55	1.74

1938-7
ROAST-CALCINE FLOTATION-CYANIDATION
GETCHELL MINE - Wark, Woodward

Purpose of Investigation:
To determine possibilities of calcine flotation preceding cyanidation.

Procedure:
A composite sample of 10 days kiln discharge was ground to 90% minus 200 mesh, diluted 4:1 and boiled 1 hour, filtered and washed. The pulp was floated with #208-#301 and #15.

Flotation concentrate was cyanided 48 hours at 3:1 with 1.0 NaCN solution. Flotation tailings were treated the same way. A second sample of flotation tailings were given a 24 hour wash with a 2% H_2SO_4 solution ahead of cyanidation.

Results:

Product	% Wt.	Flot. Assays Oz Au/ton	% Ext.	Unroasted Flot. Conc. Cyanidation Assay Oz Au/ton	Cy. Tailings Assay Oz Au/ton Normal	H_2SO_4
Head		.21		.445	.145	.145
Conc.	14.6	.445	31.0			
Tails	85.4	.145	69.0	.14	.05	.03
Extraction				68.5	68.5	77.8

The concentrates consisted mostly of black carbonaceous material-some free sulfide and all of the oily scum found in the head sample.

1949-5

Purpose of Investigation:
To determine possibility of calcine flotation.

Procedure:
No data given: Sample for flotation was Plant washed thickener underflow.

1940-5
ROAST-CALCINE FLOTATION-CYANIDATION
GETCHELL MINE - Wark, Woodward

Results:

	Heads	Flotation Cons.			Tails	Cyanidation		Consumption	
	Assay		Assay		Assay	Assay	%		
Date	Oz Au/ton	% Wt.	Oz Au/ton	% Rec.	Oz Au/ton	Oz Au/ton	Ext.	NaCN	CaO
25	.415	9.78	1.33	31.0	.32	.11	65.0	.80	1.50
26	.375	9.31	1.06	26.6	.30	.125	65.0	.65	2.60
27	.385	12.50	1.17	36.3	.295	.075	73.5	.55	2.30
28	.36	11.32	.81	27.7	.27	.08	70.5	.65	2.30
29	.335	11.95	1.09	35.0	.275	.105	65.0	.50	2.85
30	.39	10.6	1.05	29.3	.30	.10	66.6	.45	2.60
	Flotation heads - No. 3 Filter Tailings:								
25	.11	7.12	.28	22.5		.07			
26	.143	9.16	.36	29.2		.085			
27	.14	8.98	.38	26.2		.118			
28	.132	8.38	.38	25.0		.105			
29	.115	10.1	.205	21.7		.08			
30	.12	4.8	.255	12.6		.095			

1940-7

Purpose of Investigation:

To determine gold extraction on the flotation concentrate obtained from floating calcines for two weeks July 21 to August 6, 1940.

Procedure:

The sample of flotation concentrates was cyanided before and after roasting. The roast was as follows: 0° - 600°F in 45 min.; 600°F - 800°F in 45 minutes; 800°F - 1050°F in 45 minutes; 1050°F - 1300°F in 45 minutes.

Results of Cyanide Tests:

		Consumption		Assay Oz Au/ton		
Product	Grind	NaCN	CaO	Heads	Tails	%Ext.
Raw	65	.90	2.10	.768	.24	69.0
Calcine	65	1.05	2.50	.841	.06	93.0
Raw	325	1.20	2.40	.781	.26	67.0
Calcine	325	1.05	2.20	.821	.05	94.0

Analysis of Concentrates:

	Total Sulfur	SO_4 Sulfur	Sulfide Sulfur	As.
Raw	8.5	0.1	8.4	.52
Calcine	.63	.52	.11	.20

1942
ROAST-CALCINE FLOTATION-CYANIDATION
GETCHELL MINE

Purpose of Investigation:

To determine flotation results on plant calcine.

Procedure:

Flotation test made on wash thickener underflow and also on Plant tailings.

Results:

Test No.	Washed Thickener Underflow Heads Oz-Au	CONCENTRATES % Wt.	CONCENTRATES Oz-AU	CONCENTRATES % Rec.	Tails Oz-Au	Plant Tails Floated Heads Oz-Au	Plant Tails Floated Tails Oz-Au	Cyanide Ext. WTU.F.	Cyanide Ext. F.Tails
1	.155	5.62	.51	18.5	.13		.03		63.15
2	.175	9.5	.46	25.1	.145	.055	.03	68.3	59.4
3	.161	7.9	.41	20.1	.14	.06	.045	62.7	54.2
4	.170	7.7	.58	25.9	.135	.045	.025	67.7	61.5
5	.140	5.3	.485	19.3	.12	.06	.03	67.8	60.5
6	.135	4.5	.44	14.6	.12	.045	.035	66.7	60.2
7	.120	4.7	.315	12.3	.11	.045	.035	62.5	59.7
8	.155	6.3	.44	18.0	.135	.035	.025	77.4	66.8
9	.15	9.2	.47	28.4	.12	.04	.02	73.3	59.6

1938-6
MINERALOGICAL DATA
GETCHELL MINE - Wark, Woodward

Purpose of Investigation:

To determine the solubility of the gold in Getchell residues.

Procedure:

In May and the first half of June all daily plant residue samples were treated with aqua regia.

Results:

	Cyanidation Residues Assays Oz Au/ton	Aqua Regia Residues Assays Oz Au/ton
May	0.0563	0.0234
June	0.0594	0.0275

Some aqua regia residues assayed as high as 0.04 ounces gold on an 0.06 plant residue, while others assayed 0.01 ounces on an 0.065 cyanide residue.

1938-8
MISCELLANEOUS-GRAVITY CONCENTRATION
GETCHELL MINE - Wark, Woodward

A jig was operated on the ball mill discharge for several days with the following results:

		Assays Oz Au/ton	
	Bed	Hutch Discharge	Tails
#1	.11	.17	.13
#2	.15	.15	.12
#3		.13	.18

1938-42
OXIDE ORE-CYANIDATION
GETCHELL MINE

GENERAL HISTORY:

The very first laboratory test work done on Getchell Oxide ores showed a good gold extraction by direct cyanidation, and practically no recovery by flotation. All preliminary tests, by numerous metallurgists, clearly indicated these ores were amenable, at a coarse grind, to a sand leaching-slime agitation conventional cyanidation flow sheet.

The following flow sheet was in effect for approximately four and one half years. The ore was crushed to minus 3/4 inches and ground in cyanide solution at 70 per cent solids by two 7-ft. by 48-in. Hardinge mills at an average rate of 600 tons per day. Rake classifiers, in closed circuit with the ball mills, overflowed minus 20 mesh material at 38 per cent solids to a bowl classifier for a 325 mesh sand-slime separation. From this separation 65 per cent of the ore was a sand product and 35 per cent a slime product.

Sand leaching was accomplished in four 46 by 16-ft. vats, each with a capacity of 1000 tons. A 246-hr. leaching cycle with a leaching rate of 4 in. per hour was maintained.

Minus 325 mesh slimes were thickened in a 45 by 16-ft., two compartment thickener. The thickener underflow at 30 per cent solids was agitated in a series of three 22 by 16-ft. agitators. After repulping to 12 per cent solids the pulp was washed in a secondary 45 by 16-ft., two compartment thickener. Thickener underflow was repulped and filtered on two 14 by 16-ft. drum filters.

A most unfavorable feature of the ore was the large thickener and filter areas required for settling and filtering the slime portion of the ore. The slimes had an inherent tendency to form large gelatinous masses, locally termed 'islands'. This feature caused an endless amount of trouble in thickening resulting in high thickener maintainace and operation costs. Settling area for the slimes required between 10 and 20 sq. ft. per ton. Poor filtering characteristics resulted in a high gold soluble loss.

From 1938 to 1942 over 800,000 tons of oxide ore was milled. The following metallurgy was obtained,

	Sand			Slime			Total	
	Oz Au/ton			Oz Au/ton			Oz-Au	
	Heads	Tails	%Ext.	Heads	Tails	%Ext.	Tails	%Ext.
1938	.19	.0276	85.6	.19	.034	81.8	.0298	84.3
1939	.20	.0323	84.1	.20	.0375	81.7	.0341	83.3
1940	.22	.0347	84.4	.22	.0397	82.2	.0365	83.6
1941	.22	.0324	85.3	.22	.0382	82.5	.0347	84.2
1942	.23	.0430	81.1	.24	.0427	82.2	.0427	82.1

Sand and slime tailings were practically identical; however, the slimes had a dissolved gold loss of approximately 0.0055 oz. Au per ton which lowered the gold recovery on this portion of the ore.

Average chemical consumption was;

	NaCN	Lime (CaO)	Zinc Dust	$PbNO_3$
Lbs. Per ton	0.50	8.60	0.09	0.11

1938-42
OXIDE ORE-CYANIDATION
GETCHELL MINE

EXPERIMENTAL DATA

Regrinding:
Test work conducted on oxide ores gave the following information:

Purpose of Investigation:
To determine the gold extraction on reground leached sand tailings.

72 hours NaCN agitation gave the following results:

	Original Size 93% + 48m	-48m/96% + 100m	99% - 100m
Heads	0.032 Oz Au	0.03 Oz Au	0.029 Oz Au
Tails	.025	.03	.024

Regrinding leach sand tails gave very little additional gold recovery.

ROASTING-CYANIDATION

Purpose of Investigation:
To determine if roasting oxide ore would increase the recovery and improve the settling qualities of the oxide slime.

Procedure:
Raw Ore: ground to 65 mesh in lime water; settled; cyanided for 24 hrs. at 2:1.
Roasted Ore: Roasted at an evenly increased temperature for four hours at 400°F to 1000°F. Cooled and treated as above.

Composite Results: of daily tests conducted for approximately two months.

	Raw Ore	Roasted
Reagent Consumption NaCN	1.35	1.02
Reagent Consumption CaO	10.31	10.47
Heads Assay Oz Au/ton	0.232	0.232
Tails Assay Oz Au/ton	0.028	0.019
Sq. Ft. Settling Area required	15.1	4.2
Sulfur content	0.142	0.111
Arsenic content	0.456	0.458
Average mill tails obtained in the plant for April and May 1941	0.032	

(Soluble gold loss raises this tailing over the above tailing)

The sulfur content of the calcine is practically all sulfate sulfur while in the raw ore it is mostly sulfide sulfur.

Summary:
Roasting the oxide ore will reduce the cyanide consumption 0.33 lbs/ton of ore, and will increase the gold recovery by 0.0134 ounces. The settling area is reduced 79% and the final gravity of the thickener underflow would be raised.

1940-6
OXIDE STRIPPING-CYANIDATION
GETCHELL MINE

PROPOSED TREATMENT OF OXIDE STRIPPINGS

The first work done to determine the possible feasibility of treating the stripping from the hanging wall of the Getchell vein was done by the Merrill Company of San Francisco in the early part of July, 1939. This work was done on a grab sample taken from the "North Pit" and showed a recoverable value of $1.17 per ton. This, of course, was not a representative sample even of the stripping removed from this section, but did point out that the plan to treat this material should be investigated.

The stripping has been systematically sampled as the work progressed, and the present report covers tests made on a composite sample of the material removed to date June 1, 1940, and represents what can be done on this material of which approximately 1,500,000 tons are on the dumps.

The sample tested was screened to various sizes, and the sizings assayed to find out if a portion of it could be rejected. All of it carried enough value to prohibit this procedure unless following tests showed that no recovery could be made on rejectable portions. Tests were made on each size, as shown in the accompanying tabulation. Each of the sizes larger than 20 mesh was ground to pass this size screen and cyanided. Sizes smaller than 20 mesh were cyanided without grinding. Tests show a possible recovery of 95¢ per ton can be made with 8 hours agitation in 0.5# cyanide solution with no rejectable portions. Shorter time of agitation did not show as good results. Filtering tests show a satisfactory filtering rate. Settling characteristics are unimportant as the proposed flow sheet does not call for any thickening devices. The substitution of screens for hydraulic classifiers such as the Dorr, would make it possible to avoid dilution of the pulp to a point where filtering would be interfered with.

LABORATORY TEST RESULTS

Product Mesh	% Wt.	Assay Oz Au/ton	% Dist. $ Value	Gold values in $ Recovered by cyanidation of each size. Time of Agitation 1/2 hour	1 hour	8 hours
+4	6.5	.055	0.125	0.118	0.065	0.057
-4 +10	10.6	.065	.287	.106	.140	.149
-10 +20	7.9	.065	.168	.060	.067	.125
-20 +100	15.7	.035	.129	.047	.083	.116
-100	59.3	.025	.476	.332	.377	.498
Total	100.0	.031	1.185	0.663	0.732	0.945

Cyanidation tests were made with NaCN strengths of 0.50 #/T and 0.25 #/T of lime at a 1:1 dilution.

The settling rate varied directly with the time of agitation. After eight hours agitation the square feet of settling area required for settling was very, very high.

1939-3
MINERALOGICAL DATA
AMERICAN CYANAMID COMPANY - Merritt, Porter

Purpose of Investigation:

Three samples: sulfide ore, sulfide ore after roasting, and cyanidation residue were investigated to obtain:

1. Quantitative analysis.
2. Determination of the mode of occurrence of the gold.
3. Distribution of the gold in the cyanidation residue.

Results:

Assays	Sulfide Ore	Calcine	Residue
Au Oz/ton	0.225	0.276	0.115
Total Fe %	1.23	2.38	
Ferrous Fe %	.19	1.55	
As %	2.54	.16	
Total S %	2.35	.79	
S as SO_4	.06	.16	

Microscopical:

The rock appeared to be a silicified tuff composed largely of fine-grained quartz which contained numerous lithic fragments of volcanic rocks. The following metallic constituents were identified:

SULFIDE ORE	CALCINE
Realgar	
Orpiment	
Arsenopyrite	Arsenopyrite
Pyrite	Pyrite
Pyrrhotite	Pyrrhotite
Stibnite	
Sphalerite	Sphalerite
Galena	Galena
Chalcopyrite	Chalcopyrite
Chalcocite	Chalcocite
Covellite	Covellite
Hematite	Hematite
Limonite	
Electrum	Electrum

Realgar was the most abundant mineral constituent. A minor amount of orpiment was present in appreciable quantities. The only gold values noted occurred as the gold-silver alloy, electrum. Free grains of electrum were characterized by a coating of what appeared to be iron oxide.

Pyrite and arsenopyrite were both gold bearing. No gold was observed in the realgar. The realgar only assayed 0.021 oz Au/ton.

Microscopical: (continued)

Calcine

No realgar was observed. There were a few occurrences of finely disseminated sulfides, with the most abundant sulfide being a pyrrhotite-like, porous structure mineral. Considerable unroasted pyrite and arsenopyrite were present.

Residue

Assayed screen analysis showed the plus 65 and plus 100 mesh fractions assayed 0.328 oz. Au/ton and 0.201 oz. Au/ton respectively and carried 10.72% of the total gold. The minus 325 mesh fraction assayed 0.10 oz. and carried 51.20% of the gold.

A superpanner test assayed 6.90 oz. Au/ton and carried 28.82% of the Au.

Summary:

The gold in the pyrite and arsenopyrite is exceedingly fine grained. Part of the gold has impermeable coatings of iron or other material.

Roasting partially converts the pyrite and arsenopyrite to pyrrhotite. This product is also gold bearing and requires further oxidizing heat treatment.

The presence of free electrum in the cyanide residue suggests the presence of coated particles of electrum.

A flotation tailing, assaying 0.199 oz. was cyanided to give an 0.15 oz. tailing. When treated with HNO_3 and recyanided a 0.005 oz. tailing was obtained. This indicates the gold is associated with the sulfides and not with the gangue.

1939-3
FLOTATION-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Purpose of Investigation:

To determine the gold distribution in the ore, and its relationship to various minerals.

Procedure:

On coarse material in the ore the realgar was floated first, followed by a sulfide float with the flotation tailings being cyanide. The cyanide residue was digested for one hour at 90°C with a 25% solution of HCl to remove coatings of As, lime, Fe and also dissolve pyrrhotite. Another portion of the residue was treated with a 25% solution of HNO_3 to remove the sulfides and iron oxides. The acid treated residues were recyanided.

Results:

Products		Assays		Distribution	
	% Wt.	Au Oz/ton	% S	Au %	S %
Heads	100.00	0.215	2.55	100.00	100.00
As. Conc.	5.60	.24	24.14	6.04	52.94
Sul. Conc.	1.74	1.16	12.62	9.30	8.83
R. Tails	88.47	.199	.86	81.87	29.30
Note: Cleaner tailing not reported					
Cy. tails	88.47	.15		61.71	

Results: on fine material in ore

Heads	100.00	.117	1.23	100.00	100.00
As. Conc.	1.90	.20	18.31	3.42	28.25
Sul. Conc.	10.49	.42	8.60	41.03	41.88
R. Tails	83.72	.063	.29	45.30	19.64

The HCl leach and cyanidation recovered 33.33% of the gold and removed 11.63% of the sulfur. The nitric acid leach recovered 96.67% of the gold and removed 97.65% of the sulfur. The final residue assayed 0.005 oz Au/ton.

Summary:

These tests indicate that the majority of the gold is associated with the sulfides and that the more complete the sulfide sulfur elimination the better the gold tailing will be.

There is no evidence of gold associated with gangue.

OBJECT of Test #3

To determine if there were sulfides remaining in a Getchell plant calcine residue which could be recovered by flotation.

Details of Test:

A sulfide concentrate was floated and the tailing reground and refloated. Original sample was a -65 mesh grind. Final grind 65% minus 200 mesh.

1939-3
FLOTATION-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Results:

First sulfide concentrate assayed 0.31 oz. Au/ton and second concentrate 0.358 oz. Au/ton. The combined weight was 10.35% and the recovery was 26.38% of the Au. Tailing assay 0.06 oz. Au/ton on a 0.127 oz. Au/ton head assay.

Summary:

A more complete roast would give complete oxidation and probably a higher gold recovery.

1943-10

Purpose of Investigation:

To attempt to make a satisfactory recovery by flotation followed by cyanidation.

Procedure:

Test	Conditions	Grind	Time	Reagents
4	Float arsenic mineral then sulfides	5	5-7	F60-PO-#301
5	Pulp dispersed with Na_2CO_3 and Na_2SiO_2	5	6-5	" " "
6	Dispersed - floated same as 5	10 85%-200	5-5	" " "

Results:

		ASSAY Oz Au/ton					RECOVERY			
Test		Heads	Conc#1	Conc#2	R.Tail	Cy.Tail	Conc#1	Conc#2	Flotation	Cyanide
4		.159	.26	.49	.091		15.76	39.72	55.48	
	% wt.		9.61	12.86						
5		.152	.23	.52	.086	.063	15.33	40.53	55.88	11.80
	% wt.		.10.15	11.84						
6		.161	.23	.52	.102	.079	17.97	33.02	50.99	11.05
	% wt.		12.56	10.22						

Summary:

Flotation showed a recovery of 55.88% of the gold into a rougher concentrate assaying 0.39 oz. Au/ton. Cyanidation of the flotation tailing recovered an additional 11.80% of the gold. Consumption was 1.37 lbs. NaCN and 12.5 lbs. CaO per ton.

The arsenic flotation concentrate contained 86% of the As and 64% of the Sb.

1944-4
FLOTATION-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Purpose of Investigation:

To test various flotation and cyanidation procedures for the recovery of gold and arsenic, by floating first the arsenic, then separating the sands and slimes for separate treatment.

Procedure: Tests 40-41

Following a 20 mesh grind the arsenic was floated then the tailings were classified into plus 200 mesh sands and minus 200 mesh slimes. The slimes were floated with the slime concentrate added to the sands for roasting. Roasting was started at 550°F and brought to 1200°F in three hours and held there for one hour. The calcine was relatively free of unroasted sulfides. The calcined sands were ground to 60% minus 200 mesh and cyanided. A portion of the slime concentrate and arsenic cleaner tailings were also roasted and cyanided. Slime flotation tailings were cyanided.

Results:

Product	% Wt.	Assays Au Oz/ton	As %	Distribution % Au	As
Feed	100.00	0.167	1.98	100.00	100.00
As Cl. Conc.	4.07	.20	36.09	4.85	74.34
As Cl. Tail	2.66	.21	1.78	3.35	2.38
R. Tail	93.27	.164	.49	91.80	23.28
Sands	57.57	.153	.57	52.72	16.60
Slimes	35.70	.183	.37	39.08	6.68
Slime Conc.	8.53	.375	.93	19.15	4.01
Slime Tail	27.17	.123	.20	19.93	2.67

Cyanide Residues	% Wt.	Au	Au
Calcined Sands	54.81	.038	12.44
Calcined Slime Conc.	7.86	.043	2.26
Slime Tailing	27.17	.085	13.77
Composite Cy. Res.	89.84	.053	28.47
Total Gold Recovered			67.26

Summary:

The recovery of gold by cyanidation was 63.33% giving a residue that assayed 0.053 oz. Au/ton.

Test #41 was a similar test and gave about the same results.

Purpose of Investigation:

To improve the results of Test 40 and 41.

Procedure: Test #42

After grinding the ore to minus 28 mesh and floating the arsenic minerals the tailings were separated into sands and slimes. The slimes were floated and the sand reground to minus 200 mesh before floating. The colloidal slimes from the sands were discarded and the sands cyanided. Slime and sand concentrates were roasted and cyanided.

1944-4
FLOTATION-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Results: Test #42

Product	% Wt.	Assays Oz Au/ton	As %	Distribution % Au	As
Feed	100.00	.162	1.98	100.00	100.00
As Cl. Conc.	4.83	.28	32.57	8.32	79.45
As Cl. Tail	3.12	.22	.95	4.25	1.51
R. Tail	92.05	.154	.41	87.43	19.04
Sands	56.51	.148		50.68	
Slimes	36.54	.166		36.75	
Slime Flot. Conc.	11.21	.35		24.23	
Slime Flot. Tail	25.33	.08		12.52	
Sand Flot. Conc.	16.33	.41		41.49	
Sand Flot. Tail	39.18	.038		9.19	
Colloidal Slime from tail	7.68	.08		3.76	
Residual Sand	31.50	.028		5.43	
Residues					
Sand Conc.	17.44	.11		11.18	
Slime Conc.	10.24	.07		4.46	
Sand Flot. Tail	31.50	.02		4.50	
Composite Recovery	55.26				

Summary:

The arsenic cleaner concentrate contained 79.45% of the arsenic and 8.32% of the gold. The slime flotation tailing assayed 0.08 ounces. Conditioning with sodium sulfide and copper sulfate was beneficial to gold flotation.

By the scheme of treatment followed in Test 42 the extraction of gold by cyanidation was 55.26% and with the credit which would be obtained for the gold in the arsenic concentrate the total recovery of gold would be 62.0%.

1943-10
ROASTING-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Purpose of Investigation:

To determine the effect of size of roaster feed on the final cyanide residue.

Procedure:

The depth of the charge was about one inch. Each charge was placed in the furnace at 550°F and brought up to 1200°F. The time of roast was 2 1/2 hours, after reaching 1200°F the furnace was maintained at the temperature for one hour. Rabbling was every 15 minutes.

The calcines were ground to 1.32% on 65 mesh and 56.66% minus 200 mesh. Cyanidation was made at a dilution of 3:1 for 24 hours.

Results:

Feed 3.39% S .01% Cu

ANALYSIS OF CALCINES

Test No.	19	20	21	22	23	Getchell
Size	-35M	-10M	-1/4"	-1/2"	-1"	Calcine
Arsenic %	.57	.53	.46	.42	.43	.28
Antimony %	.11	.11	.085	.074	.06	.03
Total S %	.47	.47	.50	.58	.62	1.54
Sulfate S %	.47	.43	.43	.49	.42	.15
Wt. Loss	8.54	9.03	8.00	8.32	8.67	1.39

In the American Cyanamid calcines much more sulfur was eleminated than in the Getchell roast; however, Getchell obtained better arsenic and antimony elimination.

Cyanidation Results:

Test		Time	Consumption		Heads	Assays Oz Au/ton		% Extraction
			NaCN	CaO		Calcine	Tails	
19	-35m	24	.11	1.7	.177	.193	.043	77.72
20	-10m	24	.11	1.1	.171	.188	.038	79.79
21	-1/4"	24	.51	3.4	.178	.193	.045	76.79
22	-1/2"	24	.58	1.27	.159	.173	.038	78.03
23	-1"	24	.93	3.57	.159	.175	.038	78.29

Summary:

The tests show that the coarser the feed to roasting the better elimination of As and Sb; however, the elimination of sulfur decreased.

Cyanidation of the calcines gave uniform extractions of gold regardless of the coarseness of feed to the roast.

The coarseness of the feed to roasting had an appreciable effect on cyanide and lime consumption.

1943-10-2
ROASTING-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Purpose of Investigation:

To determine whether there was any relationship between the sulfide sulfur remaining in the mill feed and the gold extracted by cyanidation. Roasting of different depth beds was used to investigate this.

Procedure:

The charge was brought to a temperature of 1200°F and held there for one hour. The charge was allowed to cool for an hour. The calcines were ground to minus 65 mesh and cyanided for 24 hours.

					Analysis of Calcine			
Test	Min. to reach 1200°F	Min. at 1200°F	Depth of Charge	As%	Total %S	Sulfate %S	Sulfide S.	Weight %Loss
7	unroasted	-	-	-	-	-	-	-
23	150	60	1	.43	.62	.42	.20	8.7
24	30	60	1	.20	.84	.51	.33	7.0
26	30	30	1	.44	.84	.48	.36	7.5
27	150	60	5	.34	1.37	.57	.80	8.7
28	30	60	5	.41	1.83	.24	1.59	5.7
29	30	30	5	.48	2.23	.13	2.10	6.0
2	Getchell roaster calcine						1.39	
Reroasted	150	60			.80	.57	.23	

Results:

	Assays Oz Au/ton			Reagent Conc.	
Test	Calcine	Residue	% Ext.	NaCN	CaO
7	.155	.115	25.16	7.6	25.0
23	.175	.038	78.29	0.93	3.57
24	.175	.038	78.28	1.57	8.63
26	.195	.048	75.88	2.62	8.77
27	.183	.05	72.67	3.27	8.80
28	.170	.055	67.65	1.49	14.9
29	.176	.08	54.55	1.53	14.5
2 (Getchell (Calcine	.22	.076	63.81		
Reroasted		.038	82.73	.97	3.51

Relatively high extractions of gold were obtained when roasted in thin beds even when the ore was in the furnace only 60 minutes. Gold extraction decreased when roasted in thick beds.

Gold extraction is not related to arsenic elimination; however, sulfur elimination and gold extraction are related. The sulfur-gold relationship is probably the sulfur which is combined with pyrite.

Amount of sulfide sulfur which can be tolerated in the calcine is about 0.30%.

1943-10-2
ROASTING-CYANIDATION
AMERICAN CYANAMID COMPANY - Hedley

Summary:

1. Getchell Mill feed as received was roasted under various conditions to determine the effect of such conditions on the extraction of gold by cyanidation.

2. Roasting the mill feed in beds 1" thick with occasional rabbling eliminated much more sulfur than roasting in beds 5" thick at the same temperature. The elimination of arsenic however was not greatly affected by these roasting conditions; in each test about 80% of the arsenic was eliminated. Cyanidation of the calcines however indicated that there was a relationship between the sulfide sulfur in the calcine and gold extraction. Apparently for best extraction of gold no more than 0.30% sulfide sulfur should be present in the calcines. When the sulfide sulfur in the calcines was lower than 0.30%, 78% of the gold was extracted and cyanidation residues assaying 0.038 oz/ton gold were consistently obtained.

3. A sample of calcine submitted by Getchell Mine Inc., analyzed 1.39% sulfide sulfur. Cyanidation of this product dissolved only 63.81% of the gold leaving a residue assaying 0.076 oz/ton gold. When this product was roasted and the sulfide sulfur thus reduced to 0.23% the extraction of gold was increased to 82.73% and the cyanidation residue assayed 0.038 oz/ton gold.

1944-10
ROASTING-CYANIDATION
AMERICAN CYANAMID COMPANY - Park

Purpose of Investigation:

To determine the relationship between the degree of grinding the calcine from the coarse fraction of the ore and extraction of gold by cyanidation. This follows from the possible scheme of roasting the coarse fraction of the ore and flotation of the slime plus fine sand.

Procedure:

The ore was scrubbed on 35 mesh and separated into fines and coarse fractions. Roasting of the coarse fraction was made at 450°F to 1200°F in 240 minutes, and then maintained at 1200°F for 90 minutes.

Results: Cyanidation of Calcines from Coarse Ore Fractions

Feed Product	Grinding	Assays Oz Au/ton Heads	Tails	%Ext.	Hours Agit.	Consumption NaCn	CaO
+20m	None	.128	.047	63.28	144	1.31	15.7
+35m	4	.137	.057	69.52	48	1.20	19.1
+35m	10	.189	.055	70.90	48	1.30	18.8
+35m	20	.185	.047	74.53	48	.90	19.0
+14m	65	.164	.04	76.47	48	1.10	12.2
+14m	100	.157	.04	74.52	48	1.20	11.2
-14m Sand	100	.235	.047	80.00	24	1.40	17.1
-14m Sand	150	.227	.04	82.38	24	.60	18.4

Summary:

Although all of the results were not directly comparable, it was evident that extraction was a function of the degree of grinding. It was difficult to choose an economic point, although in order to obtain an extraction of 75% or over, the calcine had to be ground to minus 65 mesh. The minus 14 mesh sand was more amenable than the plus 14 mesh.

1940-6
MINERALOGICAL DATA
CANADA DEPARTMENT of MINES - Parsons

Purpose of Examination:
To study the character of refractory gold.

General Description:
The ore is highly silliceous with pyrite the most abundant sulfide. It occurs as medium to tiny disseminated particles. A small quantity of arsenopyrite is present associated with the coarser pyrite and as tiny crystals scatted in gangue. Very rare small grains of chalcopyrite occur with the pyrite and also in the gangue.

The grain size of the sulfides shows distribution down to minus 2300 mesh, or minus 6 microns. The fine pyrite of the minus 6 micron size is further distributed down to 1 micron. Approximately 47% of the sulfides are plus 200 mesh and 20% minus 2300. This 20% is approximately evenly divided into each micron size from 1 to 5.

There seems to be two ages of pyrite—an older coarse crystalline, dense pyrite, and a younger finely divided pyrite scattered throughout the gangue in stringers.

It can be safely assumed that the greater part of the gold occurs in the iron pyrite. Inability to observe any fine gold in the pyrite crystals indicates the extremely fine subdivision of the gold. (It is quite possible to see particles of gold in pyrite as fine as one tenth of a micron.)

The sample of ore examined assayed 0.445 oz Au/ton.

1940-6
FLOTATION-CYANIDATION
MINERAL SEPARATION CORPORATION - Williams

Purpose of Investigation:

To find out whether flotation would concentrate the refractory minerals into a product of small weight, this making possible the cyanidation of the bulk of the ore without previous roasting.

Procedure:

The ore was ground to 93% minus 200 mesh and floated at 23% solids with 0.3 #/t Z-5 15 minutes. The flotation tailing was agitated 21 hours at a 2.5:1 dilution with a 4.75 lb. NaCN solution. Cyanide consumption was 2.4 lbs/ton.

Results:

	Assays		Dist.
Product	% Wt.	Oz. Au/ton	%Au
Heads		.326	
Conc.	12.45	1.0	38.20
Tails	87.55	.23	61.80
Cy. Tailing		.10	56.52 on Heads 34.93%

Overall recovery by flotation and cyanidation 72.13%.

Summary:

Flotation on this ore is not effective.

34.932   38.2

1941-9
OXIDE STRIPPING-CYANIDATION
NEWMONT TESTING LABORATORY-McQuiston

Purpose of Investigation:

1. To obtain laboratory data that might be of aid in milling the Getchell Mine strippings at a profit.

2. To obtain laboratory data that could apply to profitable treatment of other low grade mineralized structures whose physical characteristics makes settling and filtering difficult, and whose mineral characteristics makes them not amenable to flotation alone.

Procedure:

1. Grinding to minus 28 mesh followed by both a metallic and a non-metallic float with the final sand portion of flotation tailing being leached, gave a total recovery into low grade concentrates plus solution of 60.5% of the gold. There was 32.8% of the values remaining with the slimes indicating that any successful treatment method would have to include cyanidation of slimes.

2. Grinding to minus 28 mesh was followed by a metallic float for recovery of refractory sulfides (which would be given a further treatment in practice) with the flotation tails being leached by 2 hour agitation. The dissolved values were recovered by adsorption on freshly prepared charcoal, and the charcoal subsequently recovered into a concentrate by flotation. This gave a total recovery into sulfide plus carbon concentrate of 80.5% leaving, 26 cents in the final residue.

3. Grinding to minus 35 mesh was followed by sand-slime separation with the sand portion being given a metallic float and the slime portion being leached by agitation. The dissolved values were subsequently recovered by adsorption on freshly prepared charcoal and the charcoal recovered as a flotation carbon concentrate. This resulted in a sand flotation tailing assaying 30 cents per ton in gold and a slime residue assaying 43 cents per ton.

Simulating grinding in practice to minus 20 mesh with cyanide and lime strengths as used in the Getchell Mill, with the equivalent of single stage filtering of a classifier overflow was carried out. The filter residue was repulped with activated charcoal and the equivalent of SO_2 gas. The object of this was to use activated charcoal in place of secondary filtration, or thickening, for the elimination of soluble loss and at the same time reactivate the sulfides so that they could be recovered by flotation of the activated charcoal, and the total sulfide plus the carbon concentrate to be given a roasting treatment ahead of additional cyanidation. This resulted in 56.0% of the gold being recovered in the filtrate and 27.3% of the gold recovered in the combined concentrate. This left a total residue assaying 17.5 cents per ton in gold.

Summary:

From a metallurgical point of view, and most probably from a cost plus tailing point of view, the foregoing test work has shown that a plant built along the following flow sheet, is indicated for the Getchell Strippings: Closed circuit grinding with cyanide and lime to 20 mesh; classifier overflow

Summary: (continued)
filtered with the filtrate going to precipitation or low gold circuit and the residue being repulped with activated charcoal and SO_2 gas; charcoal carrying the dissolved values and sulfides being recovered together by flotation, the flotation concentrate being roasted ahead of a second cyanidation period. This to be carried out in their present sulfide cyanide circuit.

The foregoing scheme should recover more values than other schemes tried to date on Getchell Strippings for the following two reasons:

1. Eliminates from 5 to 10 cent soluble loss inherent in any straight cyanidation scheme, using either filtration or thickening or a combination of the two for the recovery of soluble values from pulps similar to the Getchell.

2. Eliminates the loss in the sulfides by making it practical to roast the small sulfide content of strippings.

1943-9

FLOTATION-CYANIDATION

NEWMONT TESTING LABORATORY - Carey, Brown

Purpose of Investigation:

To try various flotation techniques, reagent combinations and different schemes of floating the sulfides, attempting to make a satisfactory tailing either by direct flotation or cyanidation of the flotation tailing.

Procedure and Results:

The sample used for test purposes was a composite kiln feed sample which assayed 0.17 to 0.18 oz. Au/ton.

Test No.	Mesh Grind	Min. Time	Conditions and Reagents	Conc. % Wt.	Oz. Au/ton Conc.	Oz. Au/ton Tails	%Rec.
7	65	17	10# Na_2CO_3 used in grind; 301-$PbNO_3$				
11a	65		Flotation of deslimed ore; " "	43.4	.24	.10	64.1
11b			Flotation of slime from 11a " "	39.2	.34	.064	77.3
14	150	20	$NaOH-CuSO_4$ " "	31.8	.264	.135	47.8
15	150	30	Cy-Tls. $Na_2S-NaOH-CuSO_4$-301-$PbNO_3$	54.5	.253	.067	82.0
17	80	20	Cy-Tls. $HCl-NaOH-CuSO_4$-301-Na_2CO_3	42.9	.313	.048	85.1
20	150	23	S & S separation; sand roasted;	40.1	.29	.04	98.6
			slime float $HCl-NaOH-CuSO_4$-301-404				
21	100		Flotation $HCl-Na_2S-Na_2CO_3$-301	47.4	.265	.062	87.7
			Roast and cyanide float tails				
28	100			42.6	.297	.024	92.4
29	48		Roast conc. with tails and cyanide		.375	.066	69.4
			Flotation-roast sand tails-refloat	32.1	.321	.06-Sand	
			slime tails				
					Slime -	.085	67.1

1943-12 C. R. Wark

33	65	Soap flotation; 301-Na_2CO_3-S 36-Oleic-A 18	23.7	.42	.12	52.0
35	35	Float carbon from sand heads; 301-$Al_2(SO_4)_3$	15.5	.22	.105	24.8
38	100	Water wash; 301-PbAc-Na_2CO_3	29.4	.364	.10	60.1
39	100	Carbon float; 301-NaOH-P.O.	44.5	.31	.07	77.8
40	65	Carbon float; 301-Na_2S-Kerosene	42.0	.31	.079	75.0
		New Test Sample: Heads 0.20 to 0.21 oz-Au				
42	100	Sulfide flotation-soak slimes 16 hrs.				
		Refloat; 301-PbAc-Na_2CO_3-Na_2S-K-P.O.	49.4	.36	.057	86.1
47	100	NaOH treatment of sand tails-cyanide		Sands	.04	
		NaOH 45#/T	37.3	.36	.085	74.2
48	100	Same as Test #47 NaOH 54#/T		Sands	.065	
					.055	82.0
				Sands	.03	

1944-1
FLOTATION-CYANIDATION
NEWMONT TESTING LABORATORY - Curry

Test No.	Mesh Grind	Conditions & Reagents	Conc. % Wt.	Conc.	Oz Au/ton Tails	%Rec.
50	100	Same as #47-total tails NaOH 59#/T	40.1	.20	.055	83.1
51	100	Same as #47-sand tails NaOH 57#/T	30.2	.44	.086	69.6
			Slime float tails		.127	
			Sand Cy. Residue		.055	
52	100	Flotation; roast 2 hrs. at 1200°F	33.6	.43	.081	75.0
			Slime float tails		.16	
			Sand Cy. Residue		.018	
54	200	Same as #47 NaOH 100#/T; 301-Na_2CO_3 Slime refloat; syntex-$CuSO_4$	40.3	.38	.084	74.5
			Slime float tails		.103	
			Sand Cy. Residue		.023	
55	65	Same as #54; NaOH 52#/T; 301-Na_2CO_3	41.8	.406	.046	88.2
56	65	Bulk flotation; 301-Nujol-Na_2CO_3-Syntex	42.9	.326	.12	67.6
61a	100	Sands; NaOH 42#/T; cyanidation; Hds.0.081			.03	63.0
61b	100	Direct cyanidation of sands " 0.081			.06	26.5
62	100	Separate S & S float; 301-Na_2CO_3-PbAc SAND	6.2	.76	.123	22.8
		SLIMES	6.8	.39	.16	12.8
65	65	Heat pulp to 100°F; 26-PbAc-Min.B Na_2CO_3	22.7	.598	.09	66.2
69	200	Cyanidation of raw ore			.175	16.7

1944-II Curry, Brown

Purpose of Investigation:

To follow up on work done at the University of Arizona of making a low weight sulfide flotation concentrate, and treating the tailings with NaOH prior to cyanidation.

Procedure:

The sample used for test work was a Getchell plant kiln feed composite from August 16 to September 27, 1944. Arsenic minerals were floated at 35 mesh, which was followed by a 200 mesh grind. After agitation with caustic for 40 hours the pulp was filtered, washed and given a sulfide float. Flotation tailings were cyanided 96 hours. Composite sample, heads assay 0.20 oz Au/ton.

1944-11
FLOTATION-CYANIDATION
NEWMONT TESTING LABORATORY - Carey, Brown

Results:

Test No.	Conditions and Reagents	Conc. % Wt.	Oz Au/ton Conc.	Oz Au/ton Tails	Rec.
79	NaCN 276#/T; 301-Na_2CO_3-PbAc	4.1	.80	.025	90.2
	Recovery of Au in As Conc.)				
	" " " " Sulfide Conc.)	6.8			7.5
	" " " " Cyanide Sol.				14.5
	" " " " Cyanide Tails				68.2
80	Sample #642 East X-cut Same				9.8
82	" " same procedure except sulfide float ahead of NaCN 180#/T.	3.3	.74	.03	90.2
83	Composite sample-As float at 20m; separate S & S; float slime; conc. added to sands roasted 2 hrs. at 1250°F; agitate with 47#/T NaCN for 24 hrs; cyanide 96 hrs.	2.5	.735	.035	90.2
		Sand + Sl. Conc.		.065	
		Slime Float Tls.		.22	
85	Same procedure as #83 except calcines were ground to minus 200 before cyanidation				
		Sand + Sl. Conc.		.03	62.8
		Slime Float Tls.		.19	
92	To produce low weight in concentrate no cyanidation minus 100 mesh grind	7.73	1.20	.113	60.7

Purpose of Investigation: Test #86

To make as low a final tailing as possible, following up on Tests #79-80-82, which gave the lowest tailings to date.

Procedure:

Arsenic flotation was at 35 mesh. After grinding to 200 mesh a sulfide float was made, with the tailings classified into sands and slimes. They were treated separately as follows:

	% Wt.	% Solids	NaCN % Sol.	Hrs. Agit.	NaCN % Sol.	Hrs. Agit.
Sand	67.0	55	10	96	1.0	40
Slime	33.0	10	8	72	1.0	40

Results:

	% Wt.	Assay Oz-Au	Cy. Res. Oz-Au	% Dist.	Total % Rec.
Heads	100.0	.19		100.00	Flotation
As. Conc.	3.5	.32		5.85	Cyanidation
Sul. Conc.	13.4	.63		43.82	96.4
Sand Tls.	55.7	.08	.01	2.90	
Slime Tls.	27.4	.16	.005	.71	
Solutions				46.72	

1944-1
FLOTATION-CYANIDATION
NEWMONT TESTING LABORATORY - Curry, Brown

Procedure: Test #37

Arsenic flotation was at 35 mesh with PbAc - C.O. - C.A. The tailings were ground to minus 200 mesh and treated with caustic prior to sulfide flotation.

Results:

	% Wt.	Assay Oz-Au	% Dist.	% Rec.
Heads	100.00	0.193		
As Conc.	3.31	.345	5.9	5.9
Sulfide Conc.	5.46	.75	20.8	20.8
Cl. Tails	13.27	.33	22.6	9.0
R. Tails	77.96	.125	50.7	29.3
Cy. Tails		.06		

Summary:

Better results are obtained when sulfide flotation is made prior to caustic leaching. Caustic soda seems to have a depressing effect on the sulfides.

1945-I

Purpose of Investigation: Test #91

To further study the effect of NaOH at different strength leaching solutions.

Procedure:

Conventional arsenic and sulfide floats were made with the flotation tailings split into several portions to study caustic strengths and the effect of straight feeding or stage feeding.

Results:

Test No	Conditions	% Wt.	Oz Au/ton Conc.	Oz Au/ton Tails	% Rec.
90	Conventional flotation	5.75	.80	.018	92.7
	Sulfide cleaner tails treated with 165#/T - consumption 72#				54.4

Summary:

Recoveries favor the high caustic strengths with straight feeding; however, consumption favors stage feeding.

1945-9
FLOTATION-CYANIDATION
NEWMONT TESTING LABORATORY - Curry

Purpose of Investigation: Test #91
To compare NaOH treatment with SO_2 treatment on a flotation tailing.

Procedure:
A portion of a flotation tailing was agitated 90 hours with 20#/T NaOH. Another portion was agitated the same time with 300#/T 6% SO_2. The pulps were filtered, washed and cyanided.

Results:

Treatment	Residue Oz-Au	Rec. %
NaOH	0.035	67.0
SO_2	0.08	24.0

1945-9

Purpose of Investigation: Test #93
To pretreat flotation tailings ahead of cyanidation.

Procedure and Results:
After a conventional arsenic sulfide float the tails were split into three portions - treated - washed and cyanided 40 hours.
The sulfide concentrate contained 7.85% by weight and assayed 1.19 oz. Au/ton. The flotation tailings assayed 0.134 oz.

Test	Pretreatment	Cy. Res. Oz-Au	% Rec.
A	NaCl 56.5#/T + NaOH 33.4#/T agitation 48 hours	0.065	51.5
B	NaOH 28.4#/T agitation 1 hr. Standing contact 168 hours	0.078	41.8
C	NaOH 55#/T agitation - hot - 24 hours	0.033	75.5

Summary:
As was proved in the Getchell Pilot Plant a satisfactory tailing cannot be made by straight flotation or by straight cyanidation of the flotation tailing; however, after leaching the flotation tailings with caustic soda a low cyanide tailing can be made.

1945-12
FLOTATION-CYANIDATION
NEWMONT TESTING LABORATORY - Curry

Purpose of Investigation; Test #102

To obtain data of the flow sheet of a 28 mesh grind; arsenic flotation; sand-slime separation; slime flotation; sands roasted for 2 hours at 1250°F and cyanided.

Results:

	% Wt.	Assay Oz-Au	Distribution % Au
Heads	100.0	0.183	100.0
Slimes	22.9		
Slime Conc.	4.2	.34	
Slime Tls.		.17	
Sand Res.		.06	

1944-10
CYANIDATION-FLOTATION CONCENTRATES
NEWMONT TESTING LABORATORY - Curry

Purpose of Investigation:
To cyanide the flotation concentrates without roasting.

Procedure:
A sample of Getchell Pilot Plant iron concentrates was treated with NaOH and cyanided without grinding.

Test #77: Agitation for 120 hours with 60#/T NaOH prior to cyanidation.

Test #78: Agitation for 67 hours with 60#/T NaOH prior to 95 hours cyanidation.

Test #84: Agitation for 48 hours at 10% solids in 5% NaOH solution prior to 96 hours cyanidation.

Results:

Test No.	Oz Au/ton Heads	Oz Au/ton Tails	%Ext.
77	0.61	.29	52.5
78	.61	.28	54.0
84	.61	.28	57.4

1944-1
FLOTATION- CYANIDATION
GETCHELL MINE - Silver

Purpose of Investigation:

To find a proper reagent set up and to determine what constituted the losses in the slime flotation tailing.

The test heads was a six weeks sample of kiln feed from the South Pit Extension.

Procedure and Results:

The arsenic minerals were floated after a 20 mesh grind. The sand portion of the arsenic flotation tailings was reground and floated separately. The slimes were also floated separately. These heads assayed 0.21 oz Au/ton; 3.91 As.

Test No.	Sulfide Flotation Conditions and Reagents	Arsenic Concentrate % Wt	Oz Au	%Au Rec.
1.	Na_2CO_3-301-PbX-242 Sand Tailings cyanided	7.62	.41	16.28
2.	" " " " Kerosene-Napthalene	11.47	.32	18.02
3.	Slimes centrifuged into granular and colloidal portions; granular portion ground and refloated separately. Reagents same as Test #1	10.67	.32	17.95
4.	Reagents same except $CuSO_4$ added - centrifuged as above.	5.61	.32	8.54
5.	Reagents same; slimes centrifuged; granular portion added to sands for regrind and flotation.	6.33	.30	8.96
6.	PbX-404-242-$CuSO_4$; Combined flotation; Conc. roasted	6.94	.32	10.71
7.	Coal-K-301-Na_2CO_3-PO; Sand-slime separation	8.02	.295	10.45
8.	Grind ahead of arsenic float; no Soda ash added to avoid pulp dispersion; $BaCl_2$ to As tails grind; Recovery was attempted rather than concentrate grade; $CuSO_4$-K-Nujol-Z3; Conc. roasted and cyanided.	9.34	.36	15.54

Test	Sulfide Concentrate					Flotation Tailings				Cyanide Tails	
	SLIME		SAND			SLIME		SAND		SLIME	SAND
No.	Oz-Au	%Rec.	Oz-Au	%Rec.		Oz-Au	%Rec.	Oz-Au	%Rec.	Oz-Au	Oz-Au
1.	0.50	18.19	0.76	39.38		0.095	13.46	0.048	11.89	-	0.014
2.	.50	19.29	.75	35.00		.125	16.10	.053	11.59	-	.025
3.	.505	21.06	-	-		-	-	.165	40.53		
					Colloidal	.14	10.79				
					Granular	.09	9.47				
4.	Combined Conc.		.634	68.45				.029	4.55		
					Colloidal	.085	6.50				
					Granular	.025	2.8				
5.	.82	8.87	.32	61.27		.11	9.48	.045	12.23		.04
6.	Combined Conc.		.63	64.05	Combined Tail.						.045
7.	.27	3.17	.635	66.40	Combined Tail.			.07	19.98		.03
					Total Residue						.045
8.	Combined Conc.		.32	75.06	Combined Tail.			.05	9.44		
					Total Residue						.035

1944-1
FLOTATION-CYANIDATION
GETCHELL MINE - Silver

Summary:

A short grind ahead of the As float shows a recovery of 86% of the arsenic. PbO yields a further recovery of the As.

Pulling a large bulk of middlings as a concentrate lowers the residue but the assay is only slightly changed.

Purpose of Investigation:

To float the realgar and orpiment at 20 mesh into a clean product; classify tailings into slimes and sands, with flotation of the slime portion. The sulfide concentrate combined with sands for roasting and cyanidation. Slime flotation tailing to be discarded to waste.

Procedure and Results:

This sample comprised a six weeks composite of kiln feed from the South Pit Extension. Mill heads averaged 0.16 oz. to 0.22 oz. with plant residues from 0.07 to 0.10 ounces. The As float was made at 20 mesh.

Test No.	Sulfide Flotation Conditions and Reagents	Arsenic Concentrate % Wt	 Oz Au	 % As Rec.
1.	Na_2SO_4-$CuSO_4$-PbO-301 (Lime and cyanide to As Float)	4.67	.05	1.17
2.	" " " " (Lime and cyanide to As Float)	4.75	.10	2.22
3.	301-PbO Cond. As tails 12 hrs. with $CuSO_4$	5.33	.22	5.74
4.	Z6-#25 (Very dirty froth)	6.67	.175	6.01
5.	$CuSO_4$-Z6-Na_2CO_3 (Soda Ash to As Float)	3.89	.30	5.48
6.	Very complicated reagent set up	6.11	.32	8.49
7.	$NaHCO_3$-Z6-PbO-$CuSO_4$-242 Lime to As Float	5.39	.26	6.40
8.	Na_2CO_3-Z6-$CuSO_4$-242 " " " "	5.67	.23	6.36
9.	" " " " -PbO " " " "	6.19	.33	10.14
10.	#301	7.49	.30	11.69

Several tests were made using S-243 (Cationic reagent) but the results were not worth recording.

1944-1
FLOTATION-CYANIDATION
GETCHELL MINE - Silver

Test	SLIME Sulfide Concentrate			SANDS			Slime Tails to Discard		Cyanide Tails	
No.	% Wt.	Oz-Au	%Rec.	% Wt.	Oz-Au	%Rec.	Oz-Au	% Au	SLIME Oz-Au	SAND Oz-Au
1.	5.25	0.76	20.27	44.83	0.18	44.66	0.127	27.09	0.11	
2.	2.00	1.28	12.07	45.00	.19	40.33	.17	32.31	.125	
3.	2.92	1.40	20.05	44.72	.18	39.46	.136	39.46	.11	
	Sands and sulfide concentrate roasted 1200°F and cyanided									.058
4.	14.89	.50	37.62	41.11	.15	31.71	.11	17.26	.096	
5.	7.78	.85	30.37	45.83	.172	36.78	.11	16.70	.07	
6.	6.44	.94	26.20	45.00	.165	32.13	.11	13.34		
	18.33	.67	72.23	Tails	.055	26.77	sands reground - floated			.024
7.	5.28	1.26	30.41				.11	18.84		
	6.17	.38	24.83	Tails	.05	8.41	sands reground - floated			.024
8.	11.00	.60	42.29	39.27	.16	31.05	.084	12.72		
9.	10.43	.62	32.21				.116	19.28		
	9.77	.66	32.06	Tails	.032	6.41	sands reground - floated			.02
10.	4.89	.92	23.48	47.89	.14	34.80	.008	8.16		

Summary:

As Flotation: Recovery of realgar and orpiment into a concentrate assaying 40% As with a recovery of 80% is possible at minus 20 mesh. The arsenic concentrate contains 2% of the total gold if cleaned with NaCN and 6% if NaCN is not used.

Activating with lead salts and soda ash improves the As recovery but also collects more gold. The best collectors appear to be PO and Kerosene at a lime pH of 7.2.

Slime Sulfide Flotation: A soda ash pH of 8.0 and usual amounts of 301 or Z-6 for collectors with #242 for a frother yield good results. Lead salts and copper sulfate appear to scavenge finely divided sulfides.

Assuming the primary sands as part of the concentration recovery - the over-all recovery, with clean concentrates is 70%. With a low grade concentrate an 80% recovery can be made.

Sand Sulfide Flotation: Grinding the primary sands; floating; cyaniding the flotation tailings; roasting and cyaniding the sand flotation concentrates yields an 0.04 oz. final tailing.

Cyanidation of Slime Flotation Tailings: The slime flotation tailing of 0.125 ounces only yielded 0.025 ounces Au with a high chemical consumption.

1944-4
FLOTATION-CYANIDATION
GETCHELL MINE - Silver

Purpose of Investigation:

To compare South Pit ores with South Pit Extension ores. Flotation in a neutral or slightly acid circuit without dispersion and the possible benefits of flotation with heavy hydrocarbons. To find out effects of various electrolytes to precipitate a colloidal arsenic sulfide, and effects of special solvent reagents on flotation and cyanidation. Coal dust and lamp black emulsions were to be tried as scavengers.

Procedure and Results:

The procedures and results for each of the eight tests are not given as all results are carefully summed up in Silver's conclusions.

CONCLUSIONS:

1. There is practically no difference in the results on the two ores.
2. Slightly improved results were obtainable in a neutral or slightly acid circuit, without dispersion.
3. The use of neutral oils (heavy hydrocarbons) served no good purpose.
4. Electrolytes, $Al_2(SO_4)_3$ - $Fe(SO_4)_3$ - $FeSO_4$ were harmful to flotation whereas $BaCl_2$ - $FeCl_3$ and Fe_2O_3 were moderately beneficial.
5. Cleaning the Fe concentrate requires 30 minutes flotation time. The addition of coal dust or lamp black emulsion cleans the froth up rapidly.

The following is a resume' of the reagents which have given the best results to date:

Realgar Grind and Float; $Ca(OH)_2$ plus PbO plus a 70.30 mixture of PO and Kerosene.

Iron Grind: Reddle plus S-9

Iron Float: $CuSO_4$ plus S-9 to maintain the froth.

Scavenger: Coal dust/Na_2CO_3 emulsion.
(S-9 is a xanthate mixture)

1944-12
FLOTATION-CYANIDATION-LABORATORY RESUME'
GETCHELL MINE - Silver

Purpose of Investigation:

To develop flotation to an economic aspect by simplicity of practice and metallurgical efficiency.

Procedure:

Flotation tests were made by the hundreds-practically every known reagent or combination of reagents were tried as well as various degrees of grinding and techniques.

Laboratory Developments:

The realgar flotation offered little difficulty yet this is an important conditioning stage for the sulfide flotation to follow. Dewatering after the arsenic float quite frequently promoted subsequent sulfide flotation showing something was removed which was believed to be molybdenum sulfate. The technique of using CaO to a pH of 8.6 to inhibit pyrite and the use of PbO to activate realgar took care of this soluble molybdenum salt. The stibnite in the ore mostly all floated in the realgar concentrate.

The sulfide float investigation had many ups and downs and reverses of opinion. Circuits ranging from a pH of 5 to 11 were investigated. A soda ash pulp dispersion was the best.

A great many reagents ranging from soaps to ferric oxide to coal dust to lamp black emulsions to aliphatic acids, etc, were used in an effort to pick up the last traces of finely divided sulfide coated particles.

$CuSO_4$ and PbX were investigated as activators but aside from consolidating the froth in the slime float any advantages were hard to pin down.

The reground granular part of the ore never needed any special assistance so that most of the work was done on the colloids.

Cyanidation tests were made on practically all flotation tailings in hopes of finding some answer to the colloidal slime problem. Cyanidation tests on the flotation tailings showed additional recoveries ranging from 0.015 to 0.04 ozs. Au.

The ultimate tailing was too high to be interesting or the cyanide recovery on the better flotation tailings too low to be economical.

Poor results by flotation practice were attributed to the difficulty to the fine sulfide coated particles of gangue and the failure to grind the granular portion of the ore to sulfide liberation.

Centrifuging removed a granular portion from the slime and permitted regrinding of this portion.

Most favorable sulfide flotation results were obtained in a high pH soda ash circuit.

The advantage of copper sulfate, as an activator, was hard to pin down.

Low residues could not be obtained without floating finely divided sulfide particles in the laminations of amorphous carbon. No reagent was found which would float these particles, therefore, there was no substitute for fine grinding.

Laboratory Developments: (continued)

On ores ranging in gold content from 0.16 to 0.20 ounces gold it is entirely reasonable to expect an overall gold recovery of 80% into all types of concentrates, and with a more carefully planned operation this might go as high as 90%.

There are the problems and costs of fine grinding which is one of adequate classification and thickening capacity which would have to be ample to take care of thickening slimes and reground material. Reagent costs are higher than normal. The end product, flotation concentrates, are of undesirable nature. The concentrates are extremely fine, settle and filter poorly and thus presents a difficult problem of preparing them for roasting. There is next the problem of roasting a very fine concentrate of high insoluble content, along with the final problem of making an economic gold recovery from the calcined concentrates.

The risks involved in the various phases of ore treatment by flotation to the final phase of gold recovery are questionable.

1944-12
FLOTATION-CYANIDATION-PILOT PLANT RESUME'
GETCHELL MINE - Silver

Pilot Plant Operations and Discussions:

The pilot plant flow sheet consisted of a 20 mesh grind for As flotation followed by a sand slime separation in a bowl classifier, with the sands to a regrind mill, and the slimes to thickening. The sands and slimes were floated separately.

After a period of adjustments both mechanical and reagent the results began leveling off and the following table summarises several weeks of operation.

The ore was never ground to the prescribed fineness of 90 to 95% minus 325 mesh, with an all minus 200 mesh product. Erratic and poor results are to be expected on a coarser grind. At no time during the entire pilot plant operation were conditions entirely favorable in the matter of thickening the slimes.

It is firmly believed that a more orderly and continuous operation would show further improvements. Standard practice is a realgar float at pH at 8.6 with CaO following a 20 mesh grind-classification at 200 mesh into sands and slimes- thickening slimes-conditioning thickened slimes with reground sands to a pH of 10.0 with soda ash and floating with standard reagents.

Standard reagents were 30% Pine Oil and 70% Kerosene for the arsenic float; and 30/70 #242/PO; Z-3, Z-6 or 301 dissolved in a 10% Soda ash solution.

The grade of concentrate could be greatly improved by cleaning; however, this was not done as efforts were entirely on recovery. Ordinary cleaning would probably increase the value by 50% without materially affecting the tailing.

In all Pilot Plant Operations a lime pH of 8.6 was maintained in arsenic flotation and a lime PH of 10 was maintained for sulfide flotation.

			Grind	
Date	**Flotation Flow Sheets**	**Reagents**	**As**	**Fe + 325**
Aug. 6-15	Arsenic flotation; tailings to conditioner; sulfide flotation; tailings to bowl classifier; slimes to thickener; slime flotation; classifier sand to regrind; sands to "	Realgar Float: CaO-PbO-K/PO Sulfide Float: Na_2CO_3-$CuSO_4$-70/30 Frother-Z6-Fe_2O_3-coal dust	30	20
Aug. 16-21	Same	Same	48	20
Aug. 22-25	Same	Same	48	20
Aug. 26-3	Same	Same	48	20 Erratic
Sept. 5-25	Same	Same plus Oronite 50	48	30

(continued on next page)

1944-12
FLOTATION-CYANIDATION-PILOT PLANT RESUME'
GETCHELL MINE - Silver

Date	Flotation Flow Sheets	Reagents	Grind As	Grind Fe + 325
Oct. 7-21	Arsenic flotation; tailings to conditioner; sulfide flotation; tailings to bowl classifier; slimes to thickener: UF to centrifuge; colloids to waste; granular with sands to regrind; sands to flotation.	Realgar Float: same Sulfide Float: same except no Fe_2O_3 or coal dust.	48	5
Nov. 15-24	Arsenic flotation; tailings to conditioner; sulfide flotation; tailings to bowl classifier; slimes to thickener; UF with sands to regrind; combination flotation.	Same	48	20
Nov. 25th.	Arsenic flotation; tailings to classifier; slimes to thickener; classifier sands to regrind; UF in reground sands combined to conditioner; combined flotation.	Same	48	33

Results:

	Heads	As Concentrates			Fe Concentrates			Slime	Tail	Sand	Tail
Date	Oz/Au	% Wt.	Oz-Au	% Rec.	% Wt.	Oz-Au	% Rec.	Au/Oz	Au%	Au/Oz	Au%
Aug. 6-15	.171	3.15	.63	11.64	24.70	.485	70.00	.057	10.06	.034	8.30
Aug. 16-21	.23	3.33	.405	5.94	26.93	.62	73.39	.097	12.49	.046	8.18
Aug. 22-25	.24	10.04	.216	9.19	20.33	.78	67.26	.114	14.48	.054	9.07
Aug. 26-3	.15	5.19	.20	7.03	34.76	.29	67.90	.072	12.84	.054	12.23
Sept. 5-25	.20	4.30	.37	8.03	20.80	.605	63.96	.099	15.86	.055	12.15
								colloids to waste)			
Oct. 7-21	.208	4.35	.47	9.81	34.65	.462	77.02	.07	2.02	.039	9.95)
								All flotation tails			
Nov. 15-24	.173	2.42	.42	5.86	27.86	.464	75.07	.044	17.27	-	-
								All flotation tails)			
Nov. 25th.	.154	2.31	.31	4.69	19.83	.59	76.17	.035	17.25	-	-)

1945-11
ROAST-CALCINE FLOTATION
GETCHELL MINE - Silver

Purpose of Investigation:

To determine the feasibility of floating the kiln discharge and circulating the concentrates back to the head of the roaster.

Procedure: Test 23k

Samples of both the kiln feed and discharge were taken.

	Size							Assays
	Plus 3/8"	6m	20m	60m	-60	As %	S %	Oz Au/ton
Kiln Feed	.14	.13	.17	.135	.195	1.37	2.96	.158
Kiln Discharge	.13	.15	.175	.18	.20	.31	1.44	.155

Cyanidation results on each screen product after a 60 mesh grind.

Kiln Discharge	.045	.055	.045	.05	.065

% Extraction Total - - - - 67.67%

After grinding the kiln discharge to 100 mesh and floating, the flotation tailings assayed 0.135 oz. Au/ton. Cyanidation of the flotation tailing gave an 0.045 oz. residue.

Summary:

Roasting the flotation concentrates gave an additional 0.015 ounces gold recovery.

Purpose of Investigation:

Many tests were run on the cyanide plant residues in an effort to find out what was the cause of poor plant recovery.

Procedure:

Mill tailings assayed 0.0715 oz. Au/ton. These tailings were ground to 100 mesh and floated. The flotation products were roasted and recyanided.

Results:

	FLOTATION			CYANIDATION	
		Assays		Assays	
Products	% Wt	Oz Au/ton	% Res.	Oz Au/ton	% Ext.
Concts.	12.94	.13	32.72	.0525	71.0
Tails	87.06	.055	68.28	.035	36.0

Total final residue 0.0372 oz. Au with a 50% recovery.

1945-11
ROASTING-CYANIDATION
GETCHELL MINE - Silver

General Discussion on Getchell Roasting Problems:

The physical side of the roasting difficulties are (1) segregation of fines and coarse which cause serious runs through the furnace and a subsequent partial roast. (2) Formation of mud balls which do not receive even the average roast.
(3) Roaster flame blanketed by dust contributing to poor heat transfer.
(4) Quenching preventing further oxidation.

Other Notable and Accepted Facts:

If roasting temperatures of 1200°F to 1400°F are reached the average mill result is attained. Very little arsenic other than that contained in realgar and orpiment is driven off in the roast.

Carefully conducted laboratory roasts seldom yield any better results than the plant. The plant calcine when subjected to an additional 4 hour period of roasting at 1400°F does yield a relatively satisfactory residue; however, this improved residue is seldom obtained in the laboratory in a continuous uninterrupted roast.

There is no evidence to show that further elimination of arsenic, sulfide sulfur by re-roasting results could be from further breaking down of gold bearing constituents in the absence of readily fusible silica.

A sample of arsenic concentrates was roasted in the usual way-self roasting for the most part-and cyanided.

	Oz Au/ton	As %	S %
Head Assay	0.52	43.00	25.44
Calcine	1.26	2.00	.49
Residue	.55	2.00	.49

In spite of elimination of 95.3% As and 99.3% S only 57.2% of the gold was amenable to cyanidation.

(23b) On the caustic soda treatment of the concentrate calcines using various strengths from 1% to 5% the molybdenum in solution appeared to be much higher in the strong solution effluent than in the weak. It is difficult, however to associate the poor gold recovery with the molybdenum content in the ore although the soluble sulfate which occurs naturally in the ore had its deleterious effect on the flotation problem.

(23c) Roasts with any sodium salt yielded residues which increased with the amount of the salts used to as low a recovery as 40.0% of the Au on the concentrates. This was definitely proven by several tests hence is an established fact.

(23f) Extremely fine grinding of the concentrate calcine cyanidation residues in fresh cyanide solution gave up an additional 10% of the Au, but not commercially feasible or good enough.

(23h) Special roasts with coal dust mixed into the feed gave improved results on the raw ore but it didn't appear possible to show a like effect on the concentrates-more often the reverse was the case.

(23i) Long period roasts and high temperature roasts both gave slightly poorer results on the concentrates and no appreciable improvement on the ore.

1945-11

Purpose of Investigation:

The following tests were made to compare the Quick Roast method with the conventional Roast - and also the need for grinding the calcines.

Procedure: Test 23a

The feed was ground to minus 20 mesh.

(1) Conventional roast at 1150°F for four hours.
(2) Quick roast in thin layers for 15 minutes.

The same tests were made but with a 1400°F roast.

Results:

Test No.	-20 Mesh Assays Oz Au/ton Heads	Tails	% Ext.	-60 Mesh Assays Oz Au/ton Heads	Tails	% Ext.
1	.236	.115	51.27	.243	.06	75.31
2	.239	.05	79.08	.249	.045	81.93
1400°F						
1	.252	.085	66.20	.248	.06	75.81
2	.251	.06	76.06	.260	.05	80.77

Summary:

Grinding the conventional roasted calcines had a very beneficial effect. The benefits of the Quick Roast are undeniable.

(23f) Extremely fine grinding of the concentrate calcine cyanidation residues in fresh cyanide solution gave up an additional 10% of the Au, but not commercially feasible or good enough.

(23h) Special roasts with coal dust mixed into the feed gave improved results on the raw ore but it didn't appear possible to show a like effect on the concentrates-more often the reverse was the case.

(23i) Long period roasts and high temperature roasts both gave slightly poorer results on the concentrates and no appreciable improvement on the ore.

1945-11

Purpose of Investigation:
The following tests were made to compare the Quick Roast method with the conventional Roast - and also the need for grinding the calcines.

Procedure: Test 23m

The feed was ground to minus 20 mesh.
(1) Conventional roast at 1150°F for four hours.
(2) Quick roast in thin layers for 15 minutes.

The same tests were made but with a 1400°F roast.

Results:

Test No.	-20 Mesh Assays Oz Au/ton Heads	 Tails	 % Ext.	-60 Mesh Assays Oz Au/ton Heads	 Tails	 % Ext.
1	.236	.115	51.27	.243	.06	75.31
2	.239	.05	79.08	.249	.045	81.93
1400°F						
1	.252	.085	66.20	.248	.06	75.81
2	.251	.06	76.06	.260	.05	80.77

Summary:
Grinding the conventional roasted calcines had a very beneficial effect. The benefits of the Quick Roast are undeniable.

1945-11
ROASTING-CYANIDATION-FLOTATION
GETCHELL MINE - Silver

<u>Purpose of Investigation:</u>

To separate the kiln feed into plus and minus 20 mesh portions. The plus size to be roasted and cyanided, and the slime portion floated.

<u>Procedure:</u> Test 23m

Heads 0.19 oz. Au/ton; As. 1.50%; S. 2.68%

<u>Results:</u> Composited

Products	% Wt.	Assays Oz Au/ton	Au %
+20 Cy. Tail.	75.66	0.055	21.75
Cy. Solution			58.50
As Conc.	3.36	.41	1.98
Fe Conc.	.94	.79	10.87
Midds	2.64	.14	2.25
Flot. Slime Tail.	14.33	.062	4.65

<u>Summary:</u>

The recovery is approximately the same as in the straight roasting of the ore. The furnaces are relieved to the extent of 20% of the normal furnace feed.

1945-11
ROASTING-CYANIDATION-FLOTATION
GETCHELL MINE - Silver

The following flow sheet is recommended after a two year investigation of the Getchell metallurgical problem:

Run of mine ore to a jaw crusher to deliver minus 4" to ore bin; from ore bin to Marcy ball mill in closed circuit with an inch screen. The undersize is again screened to plus and minus 10 mesh. Minus 10 mesh is floated, at a lime pH of 8.4 to remove the arsenic, with the tails classified into sands and slimes. The slimes thickened and floated for a sulfide recovery in a soda ash pH of 10.5 with xanthate and copper sulfate. Slime tails go to waste. The oversize from the 10 mesh screen joins the classifier sands and is a roaster feed. Kiln discharge is cooled, ground and cyanided.

Summary:

There appears to be no possibility that a simple crushing plant operation can be arranged which attempts dry crushing. Secondly, there is no justification in crushing finer than one inch for roasting. Thirdly, in the above flow sheet the greatest menace to the present type of roasting has been by-passed to flotation. Lastly, the most important problem of increased tonnage is provided for.

1944-7
FLOTATION-CHARCOAL-CYANIDATION
UNIVERSITY of ARIZONA - Chapman

Purpose of Investigation:
To determine if charcoal cyanidation was amenable to Getchell flotation Pilot Plant tailings.

Procedure and Results: Test 18.
Pilot plant slime tailings - agitated 24 hours with NaCN followed by agitation with NaCN and charcoal for 47 hours.

	% Wt.	Assay Oz Au/ton	% Au. Distribution
Heads	100.00	.141	100.0
C-Conc.	1.18	13.10	78.1
Midds	2.78	.075	1.5
Tails	96.38	.03	20.4

Charcoal concentrate after burning assayed 85.38 oz. Au/ton.

Test 19: Pilot Plant sand tailings same treatment

Heads		0.039	
C-Conc.	.907	5.58	72.6
Midds	1.47	.06	2.3
Tails	98.03	.01	25.1

Test 20: Slime tailings agitated 46 1/2 hours with NaCN followed by agitation with charcoal and NaCN for 117 hours.

Heads			
C-Conc. #1	0.901	.148	
C-Conc. #2	.447	15.07	91.6
Midds	2.48	.49	1.5
Tails	96.17	.03	.5
		.01	6.4

C-Conc. #1 burned to 94.40 oz. Au/ton

Test 21: Slime tailings treated same as Test 18.

Heads		.135	
C-Conc. #1	0.879	13.06	85.2
Midds	2.07	.03	.4
Tails	97.05	.02	14.4

Test 22: Sand tailing - procedure same as Test 19.

Heads		0.031	
C-Conc.	0.442	5.83	83.2
Midds	.98	.03	1.0
Tails	98.58	.005	15.8

Summary:
My previous tests 11 and 16 indicated that 18% of the Au in the Sand tailings and 42% of the gold in the Slime tailings was recoverable by the charcoal process. The recent tests suggest that these figures are 70% and 90%. The charcoal floats essentially, completely and rapidly. The three unfavorable steps are (1) Cost of caustic soda (2) Pulp dilution (3) long periods of agitation.

1944-11
FLOTATION-CHARCOAL-CYANIDATION
UNIVERSITY of ARIZONA - Chapman, McQuiston

Purpose of Investigation:
To determine the merits of charcoal-cyanidation and to determine if caustic soda consumption could be cut to practical amounts.

Procedure and Results:
Test 30: Slime flotation tailings - Confirmation of Test 21.
The pulp was conditioned with 21#/T of 90% NaOH for 45 hours followed by charcoal NaCN for 48 hours. Consumption was 18.4# NaOH; 1.75 #NaCN (due to CuSO$_4$)

	% Wt.	Assay Oz. Au/ton	% Au Distribution
Heads	100.00	1.24	100.00
C-Conc #1	0.713	14.104	81.2
C-Conc #2	0.345	.788	2.2
Midds	3.224	.04	1.0
Tails	96.462	.02	15.6

Test 31: To determine if NaOH and Charcoal - NaCN treatments could be combined. Slime pulp agitated simultaneous with 21 pounds NaOH, 3.45 pounds of NaCN, and 10 pounds charcoal for 65 hours.

Heads	100.00	.132	100.00
C-Conc. #1	0.945	8.48	60.6
C-Conc. #2	.462	.42	1.5
Midds	3.33	.06	1.5
Tails	95.93	.05	36.4

Test 32: Raw Ore: Following the realgar float the thickened tailings were agitated 43 1/2 hours with a NaOH consumption of 19.6 lbs. The charcoal-cyanidation treatment followed the caustic treatment for 48 hours. Cyanide loss was 0.46 pounds. Conditioning with CuSO$_4$ and flotation of sulfides followed charcoal-cyanidation.

Heads	100.00	0.185	100.00
Realgar Conc.	5.82	.256	8.1
C-Conc.	1.88	4.375	44.3
Sul-Conc.	5.70	.60	18.5
Tailings	74.10	.06	29.1

These results confirm Test #29 in which an 0.06 oz. tailing was made.

Test 33: The colloidal portion of the Pilot Plant slime concentrate was agitated with NaOH for 42 hours followed by charcoal cyanidation for 48 hours. NaOH consumption was 55 pounds and NaCN was 6.7 pounds.

Results: Heads 0.36 ounces with charcoal recovering 85.0% of the gold. The residue assayed 0.05 ounces. These results compare with Test #28 which showed an extraction of 82.0% with a 0.06 ounce tailing.

Test 34: Raw Ore: This test differed from Test #32 only in the manner of conditioning the pulp for sulfide flotation. NaOH consumption was 21.6 pounds and NaCN was 0.60 pounds. The tailing assayed 0.06 ounces the same as on test #32.

Test 35: Raw Ore: To determine the possibility of a three-stage flow sheet - realgar float - sulfide float - charcoal cyanidation.

The realgar float was made with B-23 and K. Tailings were conditioned with soda ash and a sulfide float made, then thickened and agitated 36 hours with 25 lbs. NaOH per ton followed by charcoal agitation for 48 hours. NaCN consumption was 0.50 pounds.

	% Wt.	Assay Oz Au/ton	% Au Distribution
Heads	100.00	0.182	100.00
Realgar Conc.	5.69	.20	6.3
Sul. Conc.	11.12	.84	51.3
Midds	9.65	.22	11.7
C-Conc.	.63	6.12	21.3
Midds	.25	.93	1.5
Tails	72.66	.02	7.9

Note: Sulfide midds not added to cyanide feed.

Test 36: Slime Tailings: To determine the possibility of decreasing the NaOH treatment to 12 hours. The tailing assay was 0.035 giving an extraction of 68% of the Au. In Test #31 45 hours NaOH treatment gave a tailing of 0.02 oz.

Test 37: Raw Ore: To determine the possibility of combining the flotation of charcoal and sulfides. NaOH agitation for 43 hours was followed by charcoal-cyanidation for 48 hours. The tailing assay 0.092 oz. Au/ton.

This method cannot compete with flotation of sulfides preceding charcoal-cyanidation.

Test 38: Raw Ore: To eliminate the middling sulfides and to use the same pulp right through to try and offset any fouling by soluble salts.

Heads		.188	
Realgar Conc.	5.25	.256	7.2
Sul. Conc.	11.94	.802	51.0
C-Conc.	4.41	1.195	28.1
C-Midds	.43	.452	1.5
Barren Sol.		Trace	
Tails	78.41	.03	12.2

Test 39: Raw Ore: This test checked the above results very closely. An 0.03 tailing was made on this test.

1944-11
FLOTATION-CHARCOAL-CYANIDATION
UNIVERSITY of ARIZONA - Chapman, McQuiston

Summary:

The following is an average test.

	% Wt.	Assay Oz Au/ton	% Au Distribution
Heads		.18	100.00
Arsenic Conc.	5.55	.23	7.1
Sul. Conc.	12.23	.74	49.9
C-Conc.		2.22	26.6
Tailings		.03	16.4

Charcoal concentrates should assay 13.19 oz. Au/ton and burn to 73.28 ounces. The final tailing could probably be reduced below 0.03 ounces.

There was no evidence of fouling the charcoal. NaOH consumption was approximately 20#/ton and NaCN approximately 0.50 pounds per ton ore.

1943-3
FLOTATION-CHARCOAL-CYANIDATION
UNIVERSITY of ARIZONA - Chapman, McQuiston

Purpose of Investigation:
To compare results from normal cyanidation with those of charcoal cyanidation.

Procedure: Tests 5 and 6;
A sample of Getchell calcine with the sulfides removed by flotation were cyanided for 44 1/2 hours with 8# CaO; 2# NaOH; 1.5# NaCN.

Results:

	Normal NaCN Res.	Charcoal NaCN Res.
Heads 0.146 oz. Au	0.05 oz. Au	0.045 oz. Au

The grade of charcoal before burning was 10.96 ounces and 19.92 ounces after burning.

Procedure: Tests 7 and 8;
A sample of Getchell calcine-classifier overflow was agitated 46 hours with 8# CaO; 2# NaOH and 2.5# NaCN.

Results:

	Normal NaCN Res.	Charcoal NaCN Res.
Heads 0.17	.055	.045
24 hours agitation		.050

The grade of charcoal concentrate was 4.59 ounces before burning.

1945-4
FLOTATION-CHARCOAL-CYANIDATION
GETCHELL MINE - Chapman

Purpose of Investigation;
To try charcoal-cyanidation in the Getchell Cyanide Plant on large scale operation.

Procedure;
Three mill tests were made on plant calcines. The ground calcines in Test 3 batch agitated in a 16' x 16' Dorr agitator. A 60 ton batch was agitated at 50% solids with 6 lbs. $Ca(OH)_2$; 2 lbs. NaOH; 4 lbs. NaCN; 8 lbs. Charcoal per ton of ore. Agitation was 40 hours. Charcoal flotation was made in a 10 cell M. S. flotation machine with provision for cleaning and recleaning.

Results;
The first two test results were showed poor gold recovery, which was to be expected because lead acetate was not used to precipitate soluble sulfides, and the solutions became so foul the gold dissolution stopped.

Test #3:

Heads		.175 oz. Au/ton	
Cons.	2.68 % Wt.	4.475 " " "	68.53 % Au Rec.
Tails		.0566 " " "	31.47 " " "

Summary: By G. H. Wigton

Compared with conventional cyanidation the following deductions were made;

		Costs	Return/Ton Ore
Heads	.1975 oz. ton		
Plant Practice Residue	.0701 " "	$2.765	$4.46
Char. Cy. Residue	.0606 " "	2.97	4.36

Note; Net return on charcoal concentrates figured on 90% of gross value, which is net smelter return.

Summary: By T. G. Chapman

WASHED TAILINGS

Charcoal-Cyanidation	Standard Cyanidation
0.0566 oz. Au	0.075 oz. Au

Although a two day comparison gives nothing more than an indication it is encouraging to note that charcoal-cyanidation is favored with respect to tailing assays.

1945-6
FLOTATION-CHARCOAL-CYANIDATION
GETCHELL MINE - Chapman

The following tests were made to determine if Charcoal-cyanidation made a better extraction than conventional cyanidation. Tests were conducted on a laboratory-calcine, laboratory flotation tailing and mill calcine.

Results: On a Laboratory roasted calcine;

	Heads Oz Au/ton	Residue Oz Au/ton	% Extraction
Davis (Con.Cy)	.18	.088	51.1
9 (Char-Cy)	.235	.073	67.7
16 (" ")	.221	.067	69.5

Results: Cyanidation of Flotation Tailings:

Test	Heads Oz Au/ton	Sulfide Cons. Oz-Au	Sulfide Cons. % Rec.	Cyanide Residue	% Ext.	Total Extraction
4	0.234	.95	48.4	0.052	32.0	80.4
5	0.197	.85	44.6	.0433	36.1	80.7
10	0.18	.85	44.9	.04	35.7	80.6

Results: On Mill Calcine;

Test	Assay Heads	Assay Tailing	% Extraction
2 Normal	0.143	.0585	59.0
3 Normal	.147	.0583	60.1
1-A Charcoal	.167	.06	64.2
1-B "	.164	.058	64.6
11 "	.166	.0586	65.3
17 "	.173	.065	62.7
Average Char.	.168	.064	64.2

Summary:

No increase in charcoal-cyanidation tailing; however, there is a slight increase in heads. With a 60% extraction on head of 0.168 the normal cyanide tailing would be 0.0672 as compared to 0.0604 for charcoal-cyanide.

1945-8

Treatment of Getchell calcines by charcoal-cyanidation indicate, based on experimental data, that there is a difference of from $0.30 to $0.50 per ton in favor of charcoal-cyanidation.

I have obtained to date an extraction of 94% of the gold as bullion from the concentrate by chlorination. From 85 to 87% of the gold is readily soluble in chlorine and the remainder is apparently refractory.

1945-8
FLOTATION-CHARCOAL-CYANIDATION
UNIVERSITY of ARIZONA - Chapman

Purpose of Investigation:
To compare recent results obtained with those of 1944 using the following flow sheet. Grind ore to minus 20 mesh; arsenic flotation; thickening; 100 mesh grind; caustic-charcoal-cyanidation; sulfide-charcoal-cyanidation.

Procedure:
In 1944 a minus 200 mesh grind was used while in 1945 a minus 100 mesh grind was made.

Results:

Heads		Realgar Conc.		Charcoal Conc.		Sulfide Conc.		Tailing	Total
		Oz-Au	%Rec.	Oz-Au	%Rec.	Oz-Au	%Rec.	Oz-Au	Rec.
1944	0.182	.23	6.6	3.60	46.3	0.60	17.1	.06	70.0
1945	0.181	.25	5.4	7.41	61.0	0.29	6.5	.055	72.9

Summary:
Roasting cyanidation on the same ore gave an 0.076 oz. residue with an extraction of 62.2% Au. Charcoal cyanidation gave an extraction of 61.0 adding the realgar and sulfide concentrates to the cyanidation residue the tailing becomes 0.071.

These results show that charcoal-cyanidation recovered essentially as much gold in cyanide without roasting as the plant recovered with roasting.

1945-10

Purpose of Investigation:
To attempt to obtain a lower tailing by arsenic flotation, sulfide flotation, followed by charcoal cyanidation.

Results:

Products	% Wt	Assay Oz Au/ton	Distribution % Au
Realgar Conc.	4.36	0.31	6.7
Sulfide Conc.	17.63	.67	58.3
Charcoal Conc.	.50	11.05	27.0
Tailing + Midds	78.05	.02	8.0
	Roasting and Cyanidation		
Realgar Conc.	4.36	.31	6.7
Cy. Sol. Conc. Treatment			52.0
Charcoal Conc.	.50	11.05	27.0
Float Tail + Conc. Res.	95.95	.03	14.3

1945-10
FLOTATION-CYANIDATION-CHARCOAL
UNIVERSITY of ARIZONA - Chapman

SUMMARY:

(1) The flotation tailing was decreased to 0.02 ounces gold per ton.

(2) Considering the realgar concentrate as discard, the indicated extraction of gold in charcoal concentrate and cyanide solution resulting from the treatment of sulfide concentrate amounted to 79.0 per cent.

(3) If the realgar concentrate is roasted and cyanided the indicated extraction would be approximately 60 per cent of the gold contained in the realgar concentrate which would add 4.0 per cent to the extraction given for the charcoal concentrate and cyanide solution of the sulfide concentrate or a total indicated extraction of 83.0 per cent.

(4) If the realgar concentrate could be disposed of for the gold content, as once suggested by you as a possibility, the indicated extraction would be 85.7%.

1945-8
CYANIDATION-FLOTATION CONCENTRATES
UNIVERSITY of ARIZONA - Chapman

Purpose of Investigation:
To roast and cyanide a laboratory, and Pilot Flotation Plant sand concentrate.

Procedure and Results:
After roasting and cyanidation of sulfide concentrates were as follows:

	% Wt.	Heads Assay Oz-Au	Dist. % Au	Cy. Res. Assay Oz-Au	Rec.%
Lab. Sulfide Conc.	17.63	0.67	58.3	0.074	89.3
Pilot Plant Conc.		1.58		.25	63.3
Lab. Sulfide Conc.	7.62	.47	13.6	.036	76.9

Summary:
Referring to the roasting and cyanidation of sulfide concentrate there is, of course, some question as to whether the results can be duplicated in practice. It was necessary to use small amounts of concentrate for roasting and the roasting was necessarily done with a thin layer of concentrate in a clay dish in an assay muffle with consequent rapid removal of gases and fume. It was realized that with a thicker charge of concentrate in practice that contact between the charge and gases might result in the formation of insoluble gold compounds and that results in practice might not therefore confirm laboratory results. The recovery of gold from Getchell Pilot Plant Sand Concentrate by roasting and cyanidation amounted to 63.3 per cent with a cyanide tailing of 0.25 ounce gold per ton as compared to a recovery of 89.3 per cent and a cyanide tailing of 0.074 ounce gold per ton for the concentrate produced in charcoal-cyanidation testing. There is, therefore, some evidence that concentrates produced in connection with charcoal-cyanidation testing together with certain modifications in the cyanidation of such concentrates, will yield satisfactory recoveries.

1945-10
FLOTATION-CYANIDATION-CHARCOAL
UNIVERSITY of ARIZONA - Chapman

Purpose of Investigation:

To compare final results of realgar flotation; charcoal-cyanidation followed by flotation of the sulfides with the results from the flow sheet just presented.

Results:

Product	Weight %	Assays Oz Au/ton	Distribution %
Realgar Conc.	3.74	0.25	5.1
Char. Conc.	1.62	6.67	59.0
Sulfide Conc.	7.24	.47	18.6
Tailings	87.90	.036	17.3
		Roasting and Cyanidation	
Realgar Conc.	3.74	0.25	5.1
Char. Conc.	1.62	6.67	59.0
Cy. Solution	-	-	14.3
Tailing + Conc. Res.	91.77	.041	21.6

Summary:

(1) Considering the realgar concentrate as discard, the indicated extraction of gold in charcoal concentrate and cyanide solution resulting from the treatment of sulfide concentrate amounted to 73.3 per cent.

(2) If the realgar concentrate is roasted and cyanided the indicated extraction of gold would be increased to 76.4 per cent.

(3) If the realgar concentrate could be disposed of for the gold content the indicated extraction would be 78.4 per cent.

(4) It is my opinion that essentially all the gold in the charcoal concentrate can be recovered as bullion and also that the particular sulfide concentrate obtained with this flowsheet can be roasted and cyanided in practice.

Final Summary:

(1) Charcoal-cyanidation recovers as much gold without roasting as the Getchell plant recovered with roasting based on repeated tests of the so-called refractory ore treated in the Getchell plant Sept. 24 to 27, 1944. Clarifying this statement, if the realgar concentrate is discarded and all sulfide concentrate discarded, charcoal-cyanidation would still recover as much gold as was recovered in the Getchell plant from this ore during Sept. 24 to 27, 1944.

(2) The combination of charcoal-cyanidation followed by flotation of sulfide concentrate and subsequent treatment of sulfide concentrate recovers more gold than direct roasting and cyanidation as practiced at Getchell. In this procedure the realgar concentrate is discarded.

(3) It follows from the two above statements that the direct roasting of Getchell ore results in the formation of compounds which are insoluble in cyanide. Although positive proof is not available at this time as to the nature of the insoluble gold compounds formed I have fairly strong evidence that molybdenum is the source of the difficulty rather than silica. At any rate the assumption that molybdenum is responsible for the formation of insoluble gold compounds in roasting has proved very constructive in obtaining improved recoveries.

(4) It is my opinion that Getchell sulfide flotation concentrate (with realgar eliminated) can be satisfactorily treated for the recovery of its gold content providing interfering molybdenum is controlled.

(5) If the sulfide concentrate is removed subsequent to charcoal treatment only one step is necessary for cyanidation of sulfide concentrate.

(6) If the sulfide concentrate is removed by flotation prior to charcoal treatment two steps will be required to cyanide the sulfide concentrate.

(7) Tailing of 0.02 can be made with flotation of sulfide concentrate prior to charcoal treatment, but I have been unable to date to make a tailing lower than 0.035 with flotation of sulfides subsequent to charcoal treatment.

(8) Disposal of realgar concentrate is a problem. By roasting and cyaniding this product I have obtained 60 per cent recovery, but roasting of realgar concentrate means a plant nuisance with arsenic.

(9) My work since October 15 has been continuous and restricted to flotation of sulfides as I believe the charcoal-cyanidation phase is satisfactory. One new advance of considerable importance has been made since Oct. 15 in floating sulfides, but I want to work out the details before reporting the results. It appears; however, that the sulfide float can be made with normal time of floating and that the wildness of past flotation froths can be eliminated. With the recent new development there is a very good possibility that flotation of sulfides can be improved with respect to recovery.

(10) It appears that there is a good chance to treat Getchell ore with a 65-mesh grind and with 15 lbs. caustic per ton. I am also working along lines to reduce the time of agitation for both caustic and cyanide treatments from 4 days to 2 days.

Summarizing, it is my opinion that much progress has been made since our work of November, 1944 and that there is a good chance to work out a satisfactory flow sheet in the near future.

1944-8
FLOTATION-GRAVITY CONCENTRATION
DENVER EQUIPMENT COMPANY - Gisler

Purpose of Investigation:

To determine the advisability of conducting an extensive ore testing program to work out the most economical method of ore treatment.

Procedure: Test #1.

After crushing to minus 10 mesh the ore was passed over a mineral jig. The jig tails were reground to minus 20 mesh and again passed over the jig. The tailings were ground to minus 65 mesh and floated with the flotation tailings passing over a table.

Time of flotation was 13 minutes using - Floto-Tarol #1 and Z-6 for reagents.

Test #2.

Two stage flotation of 8 minutes and 14 minutes. Concentrates were cleaned. Reagents used were $CuSO_4$-NaOH-PO-#15-Na_2SiO_2-PO-Z8.

Results:

Test #1.

Products	% Wt.	ASSAY Oz Au/ton	Dist. % Au
Heads		.16	
Jig Conc.	2.05	.28	3.58
Tailings		.157	96.42
Flot. Conc.	13.94	.405	35.39
Flot. Tails		.116	61.03
Table Conc.	.45	.46	1.32
Sand Tails	36.86	.09	21.51
Slime Tails	46.70	.13	38.20

Test #2.

Heads		.16		
Conc. #1	14.00	.35	31.90	(65 mesh grind)
Conc. #2	4.50	.44	12.9	(325 mesh grind)
Mids	31.00	.16	32.2	
Tails	50.50	.07	23.0	

Summary:

In Test #2 practically all free sulfides were recovered in the first concentrate at a 65 mesh grind. After regrinding the tailing a considerable amount of a black mineral floated with fuel oil. Chemical tests indicates this black mineral is graphitic in character, and contains considerable gold value.

Considering present plant practice the removal of graphite by roasting requires a high temperature and long time roast. If the graphite is not removed it interfers with gold extraction.

1945-5
ROASTING-CYANIDATION
GETCHELL MINE - Wigton, Davis

Purpose of Investigation:

To study the effect of eliminating excess air in the roaster. Comparative tests were run with various degrees of oxidation.

Procedure and Results:

The laboratory roasting furnace was reconstructed to make tests that duplicate the chemical atmospheric conditions that prevail in the rotary kilns used in milling operations.

A 10 mesh feed was roasted one hour at 1050°F. Calcines were ground to minus 48 mesh and cyanided 42 hours. The ore had the following analysis:

Gold	0.115 oz. per ton
Arsenic	0.9%
Sulfur	2.61%

Test No.	Atmospheric Conditions	Results: Assays Oz Au/ton	
		Tailings	Extn.
1	Reducing atmosphere; calcine washed	.03	72.73
2	Oxidizing roast then reducing roast	.025	78.3
3	Oxidizing roast; sulfating; H_2SO_4 10#/T leach ;8 hrs.	.045	60.9
4	#3 Calcine; washed; cyanided; ground	.025	78.2
5	Oxidizing; Reducing Roast; Grind with $Na_2S_2O_3$ 20#/T	.025	78.3

Summary:

The results of the tests indicate a greater elimination of arsenic and sulfur by the use of a reducing atmosphere; however, the subsequent gold extraction remained the same. The use of a slightly oxidizing atmosphere during the first part of the roast, followed by a slightly reducing atmosphere during the finishing stages offers the following advantages: (1) Improved roasting will result in improved settling and filtering during subsequent cyanidation. (2) Reduction of excess air will result in roasting and will reduce fuel cost per ton ore.

Purpose of Investigation:

To study the effect of sulfur dioxide treatment on the calcines with the object of converting refractory gold bearing compounds to form that yield to cyanidation.

Procedure and Results:

Tests 14 through 18 were made of a laboratory roasted calcine. A 3/4 inch feed was roasted approximately one hour at 1050°F. Cyanidation was on a minus 48 calcine for 40 hours. Tests 19 through 24 were on a plant roasted calcine.

1945-5
ROASTING-CYANIDATION
GETCHELL MINE - Wigton, Davis

Test No.	Treatment of Calcine	Results Assays Oz Au/ton Heads	 Tails	 %Ext.
14	SO_2 gas agitation of calcine for 30 min. 2:1 Q/R Roast	.115	.01	91.3
15	" " " " " " 15 min. 2:1	.18	.03	83.5
16	" " " " " " 15 min. 2:1	.23	.025	89.0
17	H_2SO_3 treatment of raw ore (6.6%) .5#/T Evaporated no wash	.21	.045	77.5
18	H_2SO_3 treatment of raw ore (6.6%) by Pellizing	.21	.05	76.2
19	" " of mill calcine by 1:1 of 3.3% H_2SO_3	.23	.035	84.4
20	" " " " " " 8% of above H_2SO_3	.23	.06	73.9
21	" " " " " " 16% of " "	.23	.05	78.3
22	" " " " " " 24% of " "	.23	.04	82.6
24	" " " " " " 32% of " "	.23	.06	73.9
25	" " as 24 except washed 3 times.	.23	.05	78.3

Summary:

The treatment of Getchell calcine by sulfur dioxide, either as gas or as a sulfurous acid solution, undoubtedly results in a substantial increase in gold extraction by subsequent cyanidation. The lowest tailings have been produced when the tailings were vigorously agitated by an excess of sulfur dioxide gas, when a well-roasted calcine was treated. It is indicated that, after the treatment with sulfur dioxide and before cyanidation, soluble salts should be removed by washing. Although the evidence is not conclusive, it is indicated that sixty pounds of sulfurous acid per ton ore may reduce the gold in the cyanidation tailing about .03 oz. on an ore carrying .20 oz. gold per ton. The cost of sulfur dioxide wet treatment is estimated to be $0.75 per ton of ore.

Purpose of Investigation:

To study different types of calcines and different methods of preheating the calcines.

Procedure and Results:

Calcines were ground to minus 48 mesh and cyanided for approximately 42 hours.

Test No.	Conditions and Pretreatment	Size	Min. Time	°F Temp.	Results Oz Au/ton Heads	 Tails	 %Ext.
6	Ox.; Red.; SO_2 (Sulfating roast)	3/4	60	975	.21	.06	66.7
7	#6 Calcine floated; cyanide tails	3/4	60	975	.177	.055	66.1
8	#6 Calcine neutralize with CaO before float	3/4	60	975	.23	.065	71.5
9	Reduction with Sodium Sulfide	3/4	60	975	.23	.065	71.5
11	Ammonia cyanidation	3/4	60	1000	.18	.045	75.0
12	High temp. roast in reducing atmosphere	10	70	1360	.21	.105	48.7

Procedure and Results: (continued)

Test No.	Conditions and Pretreatment	Size	Min. Time	°F Temp.	Results Oz Au/ton Heads	Tails	% Ext.
23	Ox. 900° 40"; Red. 1000° 30"; Ox. 1000° 30"	10	Plant		.21	.06	71.4
26	H_2SO_4 leach 3% at 1:1 dilution	10	"		.23	.035	84.4
27	NaOH 20#; Al dust 0.25#; grind; cyanide	10	"		.23	.05	78.3
28	" " " " 5.00#; " "	10	"		.23	.05	78.3
29	Direct cyanidation by standard practice	10	"		.23	.065	71.7
31	" " " " "	10	"		.23	.065	71.7
39	Ammonia in place of lime - Foul	10	70	1360	.21	.075	67.3
41	Ammonia; to grind; agitation 24 hours		Plant		.23	.06	73.8
42	Ammonia; NaOH; CaO to agitation		"		.23	.055	63.0
43	H_2SO_4 6% at 1:1; washed		Lab.		.21	.04	81.0
44	Reroast at 1360° calcine ; oxidizing cond.		30	1040	.21	.11	47.6
45	Red. 45" 1260°; ox. 30" 1180°				.21	.095	54.7
49	Simple cyanidation	1/4	60	1020	.195	.06	68.7
50	Niter oxidizing roast 80#/T		30	1040	.195	.085	64.5

Test No.
40 Centrifuge Pond Tails Heads 0.06;1.5% Sand 0.05; Coll. Slime 0.065
48 " " " Heads 0.06; 30% Sand 0.065; Slime 0.06

1945-6

Purpose of Investigation:
To determine at which point extraction is aided by a caustic soda leach of the calcines.

Procedure and Results:
A plant calcine was leached with NaOH and cyanided for 40 hours.

Test No.	Pretreatment of Calcine	Results Oz Au/ton Heads	Tails	% Ext.
51	NaOH - 16 lbs. per ton ore	.195	.095	60.0
61	NH_3 on #51 Calcine at	.24	.065	72.3
62	Reroast #51 calcine at 10m 20 min. at 1000°	.24	.06	75.0
67	Evaporate with CaO - NaOH	.24	.07	70.8

Summary:
Aerating calcines with strong caustic solutions showed a small but unattractive improvement in the tailing. Caustic consumption, as indicated by titration of the solutions with standard acid before and after treatment, varied from 36 pounds to 45 pounds caustic per ton of calcine.

1945-6
ROASTING-CYANIDATION
GETCHELL MINE - Wigton, Davis

Purpose of Investigation:

To find practical and economic use of sulfurous acid.

Procedure and Results:

Test No.	Pretreatment of Calcine	Roasting Cond. Size	Min. Time	°F Temp.	Results Oz Au/ton Heads	Tails	%Ext.
63	H_2SO_3 (3%) leach 1:1 for 1 hour	Plant Calcine			.24	.045	
65	" heat 10m calcine to nearly dry	"	"		.24	.07	70.8
66	" heat 10m calcine more acid	"	"		.24	.06	75.0
68	" leach - minimum amount	1/2"	50	1000	.195	.048	79.3
73	" 15# grind - leach 150 minutes	#52 Calcine			.23	.06	73.9
74	" 15# leach - grind in water	"	"		.23	.06	73.9
76	" 15# long standing 8 day contact	Plant Calcine			.17	.067	74.7
83	" 124 lbs. agitation with Pond Tailings	"	"		.08	.03	62.5

Summary:

Treatment of ground calcine in the form of a wet pulp by large amounts of sulfuric acid, sulfurous acid, or caustic soda yields comparatively low tailings, but so much reagent is required that there is little indicated net gain in profit.

Purpose Of Investigation:

To see if Wetting Agents promote better gold extraction.

Procedure and Results:

Plant calcines were ground and treated with different types of Wetting Agents then cyanided.

Test No.	Pretreatment of Calcine	Results Oz Au/ton Heads	Tails	%Ext.
69	OWA 0.10 pound per ton	.24	.06	75.0
70	KRM 0.10 pound per ton	.24	.075	68.7
71	X-1 0.10 pound per ton	.24	.065	72.9
72	None; water grind; wash; regrind NaCN	.23	.06	73.9
80	Grind with OWA 0.10 lb/ton	.17	.07	58.8
81	Grind with Ms 0.10 lb/ton	.17	.07	58.8
82	Grind with OS 0.10 lb/ton	.17	.067	59.3

Purpose of Investigation:

To determine if long time 'standing contact', as would be obtained in a stagnant pool, was an aid in gold extraction.

Procedure and Results:

A plant calcine was ground to 48 mesh then left standing for a period of time as follows: Cyanidation was 40 hours.

1945-6

ROASTING-CYANIDATION
GETCHELL MINE - Wigton, Davis

Test No.	'Stagnant' Conditions	Results Oz Au/ton Heads	Tails	% Ext.
75	Lime contest for 7 days	.17	.10	58.8
76	" " " 15 days	.17	.047	74.7
132	" " " 15 days 40#/T	.183	.06	67.2
	Normal plant tailing		.06	67.2
135	NaOH - 10% at 2.5:1 2 days leach on 10m	.185	.05	73.0
137	" 2% " " 1 day leach on 10m	.185	.05	73.0
139	Lime 80#/T contact for 4 weeks	.183	.055	70.0
136	NaOH 40#/T contact for 15 days	.185	.065	64.8
140	NaOH 20#/T " Flotation Tails for 22 days	.183	.06	67.2
141	NaOH 20#/T " for 15 days	.115	.045	66.9
152	Lime 80#/T " for 48 days	.183	.06	67.2
153	NaOH 20#/T " for 42 days	.183	.065	63.5

Summary:

Stagnant Peel conditions with alkalis shows slight improvement in extraction, although not enough to justify its adoption. The pulp does not change color during this treatment.

1945-7

Purpose of Investigation:

To find out what effect bleaching of the wet pulp from the raw ore or calcine has on subsequent cyanidation.

Procedure and Results:

Test No.	Bleaching Treatment	Roast. Conditions Size	Min. Time	°F Temp.	Results Oz Au/ton Heads	Tails	% Ext.
97	Lime aeration for 40 hours	Plant			.17	.067	60.0
98	Lime - NaOH aeration for 40 hours	"			.17	.067	60.0
99	Lime NaCl aeration for 40 hours	"			.17	.067	60.0
103	Lime 20#/T in grind	1/2	45	1000	.175	.08	55.9
104	" " " "	10	30	1000	.15	.066	56.0
105	Raw Ore - cyanide excess MnO_2	None			.115	.08	26.1
106	Lime 10#/T in grind - agitate with chlorinated lime - 1#/T MnO_2 cyanide	1/2	60	1000	.175	.097	44.6
107	Same except 1.5#/T PbAC added	10	30	1000	.15	.077	50.0
112	H_2SO_4 aeration - 22 hrs. aeration CaO	Plant			.183	.083	54.6
116	NaC "	"			.183	.128	30.0
117	Aeration at 7.0 ph ahead of cyanidation	"			.134	.126	-
120	SO_2 percolated thru damp calcine	"			.183	.066	64.0
123	NaOH used in cyanidation	"			.185	.08	57.0

1945-7
ROASTING -CYANIDATION
GETCHELL MINE - Wigton, Davis

Summary:

Bleaching can be accomplished by simple aeration at a pH of 7.0 to 8.0; the grayish black pulp from the sulfide ore or calcine can be changed to a yellowish-brown to cream color, although no substantial oxidation of sulfides occurs. However, no increase in extraction has been obtained by bleaching in this manner.

Purpose of Investigation:

To investigate further any possible advantages from other schemes of pretreatment.

Procedure and Results:

Grind ahead of cyanidation was minus 48 mesh.

Test		Roasting			Results	
No.	Conditions-Pretreatment	Min. Time	°F Temp.	Oz Heads	Au/ton Tails	%Ext.
142	Flot tail roasted after As Float	70	1050	.24	.065	72.0
143	Flot tail roasted after As-Fe Float	70	1050	.13	.035	73.0
144	Grind -35m; filter roast	135	1025	.27	.07	74.1
145	Amalgamation prior to roasting	30	1200	.145	.087	40.0
146	Standard roasting-cyanidation	30	1050	.145	.065	55.2
147	Volatilization by Hydrocarbon reduction	65	2030	.145	.09	72.0
148	HNO_3 leach at 2.5:1 for 30 minutes	None		.145	.04	72.4
149	Aqua regia leach at 2:1 for 30 minutes	"		.145	.04	72.4
150	SO_2 - agitated at 65m for 30 minutes	"		.145	.07	48.0
151	Aqua regia - boiled for 20 minutes	Plant		.145	.046	70.0
160	Fluorspar pelletized with HCl	20	800	.165	.05	69.1

Summary:

Roasting flotation tailing showed reduction in tailing assay, particularly when an iron concentrate was also removed.

1945-11

Purpose of Investigation:

To determine if the Raw Ore would yield a good extraction to cyanidation after treatment.

Procedure and Results:

Test			Results	
No.	Pretreatment of Raw Ore	Oz Heads	Au/ton Tails	%Ext.
161	CaF 200#/T - 500#/T HCl - agitated 12 hours	.15	.06	60.0
163	H_2SO_4 100#/T agitated 12 hours	.16	.085	48.0
164	" 50#/T-CaF for 12 hours (50#/T)	.16	.07	60.0
165	" 100#/T - 100#/T CaF for 12 hours	.16	.07	60.0

1945-9
ROASTING-CYANIDATION
GETCHELL MINE - Wigton

Summary:

Although the present process of roasting and cyanidation has achieved a measure of success in the past, the resulting recovery has been low, the cost high, and it will not produce profit on those ores assaying less than 0.18 oz. gold per ton. Nevertheless, a more satisfactory process has not yet been found.

Research has been conducted to determine the causes of low extraction. They may be listed, in order of decreasing importance, as follows:

1. Association of much of the gold in the ore with siliceous material in such a way as to prevent contact with the gold solvent.
2. Association of gold with sulfide minerals, due to incomplete roasting.
3. Association of gold with iron arsenates formed during the roasting.
4. Foulness in cyanide solutions.

1. Siliceous Gold

Aqua regia will dissolve only 50% to 70% of the gold in some of these raw ores that are available for future treatment, although it is a solvent for all forms of gold. However, if the siliceous material is first removed by treatment with hydrofluoric acid, aqua regia will dissolve practically all the gold. As extremely fine grinding does not accomplish the same result that is obtained with hydrofluoric acid, the association of such gold with siliceous material may approacy a state of solid solution. I have called such gold "siliceous gold".

2. Gold Associated with Sulfides

This type of gold needs no particular comment. Anything that is done to obtain a better roast should increase the extraction of gold associated with sulfides.

3. Gold Associated with Iron Arsenates

In roasting arsenical gold ores, some of the gold is locked up by iron arsenates formed during the roast. The iron arsenates cannot be decomposed by high temperature alone, but reducing conditions tend to prevent their formation. Iron arsenates can be decomposed in the wet way by sulfur dioxide, alkalis, or hydrochloric for that purpose, but so much is required that its use does not have economic value.

4. Foulness in Cyanide Solutions

Foulness in Getchell cyanide solutions is caused by the presence of incompletely roasted sulfides in the calcine. Some of the soluble sulfides can be washed out before cyanidation, but foulness continues to develop during cyanidation, and must be taken care of in a chemical way.

The principal cause of high tailings is that siliceous material is so associated with the refractory gold that it prevents contact between such gold and the solvent.

Summary: (continued)

Roasting

We can expect a thorough roast to:

(1) Destroy colloidal slime, so as to permit rapid settling and filtering in subsequent cyanidation.

(2) Eliminate cyanicides, such as arsenic sulfides and ferrous salts that form thiocyanates and ferrocyanides when contact is made with cyanide solutions.

(3) Free the gold associated with sulfides for better contact with the cyanide solutions.

(4) Form iron arsenates that prevent dissolution of some of the gold by cyanide solutions. The iron arsenates can be decomposed in the wet way by sulfur dioxide, caustic soda, or hydrochloric acid. On account of the large amount of acid consuming gangue in the calcine, the only practical way of decomposing arsenates is by the use of caustic soda solutions.

We cannot expect a thorough roast to aid in removing the silica from the "siliceous gold".

1945-1
ROAST-CALCINE FLOTATION-CYANIDATION
GETCHELL MINE - Higton, Davis

Purpose of Investigation:

To obtain sufficient data for a plant installation.

Procedure and Results:

Calcines were floated and the flotation tailings cyanided. Many reagents were used with approximately the same results.

	CALCINE FLOTATION RESULTS					TAILINGS CYANIDATION				
	Heads	Concentrates			Tails	Fl.Tls.	Plant	% Extraction		
Date	Oz-Au	% Wt.	Oz-Au	%Rec.	Oz-Au	Oz-Au	Oz-Au	Fl.Tls.	Total	Plant
7	.175	9.5	.46	25.1	.145	.03	.055	79.3	84.5	66.6
8	.161	7.9	.41	20.1	.14	.045	.06	67.8	74.3	69.2
9	.170	7.7	.59	25.9	.135	.025	.055	81.4	87.4	63.1
10	.14	5.3	.435	19.3	.12	.03	.045	75.0	79.8	67.6
11	.15	7.5	.43	21.1	.13	.06	.06			67.2
12	.135	4.5	.44	14.6	.12	.035	.045	70.4	74.8	68.1
13	.12	4.7	.315	12.3	.11	.035	.045	68.1	72.0	67.6
14	.155	6.3	.44	18.0	.135	.025	.035	81.5	84.8	70.5
15	.14	10.2	.39	28.4	.11	.04	.055	63.7	74.0	66.6
16	.15	9.2	.47	28.4	.12	.02	.04	83.3	88.2	71.8
19	.186	13.5	.355	25.7	.16	.05	.065	68.8	76.6	66.6
20	.178	8.8	.47	23.2	.15	.05	.065	66.6	74.4	53.7
22	.133	7.3	.365	18.5	.115	.035		69.5	75.2	53.3
25	.155	11.5	.39	28.8	.125	.045		64.0	64.0	60.6
27	.132	5.7	.33	14.2	.12	.06		50.0	57.1	66.6
28	.137	7.0	.43	22.0	.115	.045		60.8	69.4	70.6
28	.219	10.1	.565	26.1	.18	.08		55.5	67.2	
29	.206	7.1	.605	20.8	.175	.055		68.5	75.0	75.0
30	.223	9.9	.615	27.3	.18	.055		69.5	77.8	75.3
1	.255	10.7	.59	25.0	.215	.075		65.0	73.8	
2	.133	16.7	.22	27.8	.115	.04		65.2	64.9	56.1
3	.16	10.7	.33	22.2	.14	.045		67.8	75.0	
4	.155	6.4	.31	12.8	.145	.05		65.5	69.9	68.1
5	.182	5.1	.59	16.5	.16	.045		71.8	76.5	57.5
6	.167	7.3	.38	16.8	.15	.06		60.0	66.3	64.3
7	.171	4.5	.405	10.6	.16	.055		65.6	69.2	61.7
8	.18	4.0	.54	12.0	.165	.045		73.0	76.2	65.7
9	.168	8.6	.525	26.8	.135	.045		66.6	74.6	74.4
10	.167	10.9	.35	22.8	.145	.05		65.2	65.5	
11	.171	10.2	.445	26.8	.14	.04		71.4	79.0	
12	.164	7.3	.47	21.0	.14	.045		68.0	75.7	
17	.190	9.0	.51	24.0	.17	.035		79.0	84.2	

1945-1
ROAST-CALCINE FLOTATION
GETCHELL MINE - Wigton

Summary:

Laboratory work indicates that it is possible to remove unroasted sulfides from the roasted ore by a simple and cheap flotation operation, and re-roast the small amount of flotation concentrate, about 10% by weight, before cyanidation; the flotation tailing would pass directly to the present cyanidation plant. It may be possible to return the flotation concentrate for another pass through the same roasters. Laboratory tests on kiln discharge ground to pass a 35 mesh screen, indicate that it is possible to obtain a tailing containing about .03 oz. gold per ton by floating the unroasted sulfides from the calcine before cyanidation. No change in the mechanical handling of the flotation tails in the present cyanide plant would be necessary.

1945-3

Purpose of Investigation:

To determine if the laboratory experiments of floating sulfides from the calcines could be duplicated in plant practice.

Procedure and Results:

One of the 10-cell M.S. machines was operated intermittently for some time, and continuously at the time of the Chapman test, taking the feed to one of the cyanide circuits before it was washed. Flotation tailings went on to the wash thickener and the thickened pulp to cyanidation. Concentrate was cleaned in two Denver cells, then thickened, filtered and hauled to the crusher yard, where it was mixed with new ore and passed through the same roaster. No serious trouble was encountered in flotation proper, although at times we were bothered some by fuel oil in the feed. The froth was rather tough unless one to two lbs. soda ash per ton was used. Flotation reagents were "301" and "242".

We did find, however, that we had insufficient thickening capacity; this resulted in the operators not pulling the cells as fast as they should have done, with the result that we made only about 3% concentrate by weight instead of the 7% that had been anticipated. We were just preparing to put a larger thickener into service when the order came to stop all operations.

Summary:

The cyanide tailing from the circuit in which calcine flotation was used averaged about .01 Oz. lower than the tailing from the old circuit, in which flotation was not used. The cost of the operation was a little less than 25 cents per ton, so that there was a slight profit by the use of calcine flotation.

I believe that we could have done somewhat better if we had not been limited by lack of concentrate-thickening capacity. However, it appears that, on average ore, the profit by calcine flotation will not be enough to class it as a major improvement. On some ores it seems to be quite effective, but on other ores it does little good. Its chief function appears to be to float unroasted sulfides that remained in the interior of clay balls.

1945-1
ROAST-CALCINE FLOTATION
GETCHELL MINE - Wigton

Summary:

Laboratory work indicates that it is possible to remove unroasted sulfides from the roasted ore by a simple and cheap flotation operation, and re-roast the small amount of flotation concentrate, about 10% by weight, before cyanidation; the flotation tailing would pass directly to the present cyanidation plant. It may be possible to return the flotation concentrate for another pass through the same roasters. Laboratory tests on kiln discharge ground to pass a 35 mesh screen, indicate that it is possible to obtain a tailing containing about .03 oz. gold per ton by floating the unroasted sulfides from the calcine before cyanidation. No change in the mechanical handling of the flotation tails in the present cyanide plant would be necessary.

1945-1

Purpose of Investigation:

To determine if the laboratory experiments of floating sulfides from the calcines could be duplicated in plant practice.

Procedure and Results:

One of the 10-cell M.S. machines was operated intermittently for some time, and continuously at the time of the Chapman test, taking the feed to one of the cyanide circuits before it was washed. Flotation tailings went on to the wash thickener and the thickened pulp to cyanidation. Concentrate was cleaned in two Denver cells, then thickened, filtered and hauled to the crusher yard, where it was mixed with new ore and passed through the same roaster. No serious trouble was encountered in flotation proper, although at times we were bothered some by fuel oil in the feed. The froth was rather tough unless one to two lbs. soda ash per ton was used. Flotation reagents were "301" and "242".

We did find, however, that we had insufficient thickening capacity; this resulted in the operators not pulling the cells as fast as they should have done, with the result that we made only about 3% concentrate by weight instead of the 7% that had been anticipated. We were just preparing to put a larger thickener into service when the order came to stop all operations.

Summary:

The cyanide tailing from the circuit in which calcine flotation was used averaged about .01 Oz. lower than the tailing from the old circuit, in which flotation was not used. The cost of the operation was a little less than 25 cents per ton, so that there was a slight profit by the use of calcine flotation.

I believe that we could have done somewhat better if we had not been limited by lack of concentrate-thickening capacity. However, it appears that, on average ore, the profit by calcine flotation will not be enough to class it as a major improvement. On some ores it seems to be quite effective, but on other ores it does little good. Its chief function appears to be to float unroasted sulfides that remained in the interior of clay balls.

1945-(5-6-7-9)
CYANIDATION-FLOTATION CONCENTRATES
GETCHELL MINE - Wigton, Davis

Purpose of Investigation:

To try and work out a method for treating a flotation concentrate.

Procedure and Results:

Flotation sulfide concentrates were all minus 100 mesh.

Test No.	Conditions-Treatment	Min. Time	°F Temp.	Oz Au/ton Heads	Results Tails	% Ext.
29	SO_2 Gas agitation 15 minutes; wash	30	1000	.44	.16	63.6
32	H_2SO_3 " 10 minutes; "	30	1000	.315	.19	39.6
33	Aluminum - NaOH reduction	30	1000	.44	.175	60.2
34	NaOH agitation	30	1000	.44	.18	60.0
35	Na_2SO_3 124#/T 20 hrs. agitation	30	1000	.44	.16	63.6
37	Reducing roast at high temperature	240	1300	.51	.31	39.2
D19	H_2SO_3 agitation	30	1000	.315	.19	39.6
D20	NaOH 10#/T - 0.25#/T Al dust in grind	30	1000	.44	.175	60.0
D21	NaOH treatment without Al dust	30	1000	.44	.18	60.0
D22	H_2SO_3 124#/T calcine - agitation 20 hrs.	30	1000	.44	.16	63.6
46	Reducing - Oxidizing roast	60	1200	.44	.32	29.3
47	Na_2O_2 20#/T in grind	60	1200	.44	.32	29.3
119	H_2SO_3 12#/T agitation	60	1200	.44	.18	60.0
128	High grade recleaned conc.	80	1050	1.125	.495	56.0
131	SO_2 gas agitation	45	1000	.61	.31	50.0
132	Normal cyanidation	45	1000	.61	.30	51.0
134	Realgar concentrates	60	1000	1.47	.86	41.5
162	CaF 1#/T - HCl 12.5#/T agitation 12 hours	Calcine		.64	.10	84.2

Summary:

The concentrate seems to be more refractory than the original ore, which suggests that the gangue constituents of the ore may have a beneficial effect, and that closer contact of the gangue with the gold bearing minerals may produce a calcine that is less refractory.