CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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60.43

Volume 3 ; Book 4

TOMBSTONE

Mining District

Cochise County

ARIZONA

Richard F. Hewlett Progress Report
April 11, 1979

Southwestern
Exploration
Associates

Mineral Exploration &
Natural Resource
Consultants
Tucson, Arizona

SUMMARY

Consultants in:
- Hydrometallurgical recovery
- Heap and conventional leaching
- Precious and base metals
- Uranium/Vanadium
- Tungsten

Worldwide Mobilization

Division of
Southwestern Exploration Associates

4500 E. Speedway, Suite 14
Tucson, Arizona 85712
(602) 795-6097

Richard F. Hewlett
Vice President and General Manager
Chemical Engineer
Mining Engineer

S.E.A. Hydromet, Inc.

April 11, 1979

Messrs. Tom Schloss
and Dwight Lee
FAMCO
1700 Broadway
New York,
New York (10019)

Dear Tom and Dwight:

Based upon my experience at Tombstone with the heap leaching project in the early testing phase, the following recommendation is made:

1. Proceed with the next phase of late-stage testing and early-stage production as soon as possible.

The above recommendation is made based on the following recent results and consequential conclusions:

1. Ore potential has been adequately proven.

2. Various solvents other than but also including cyanide have been proven effective with the Tombstone ores.

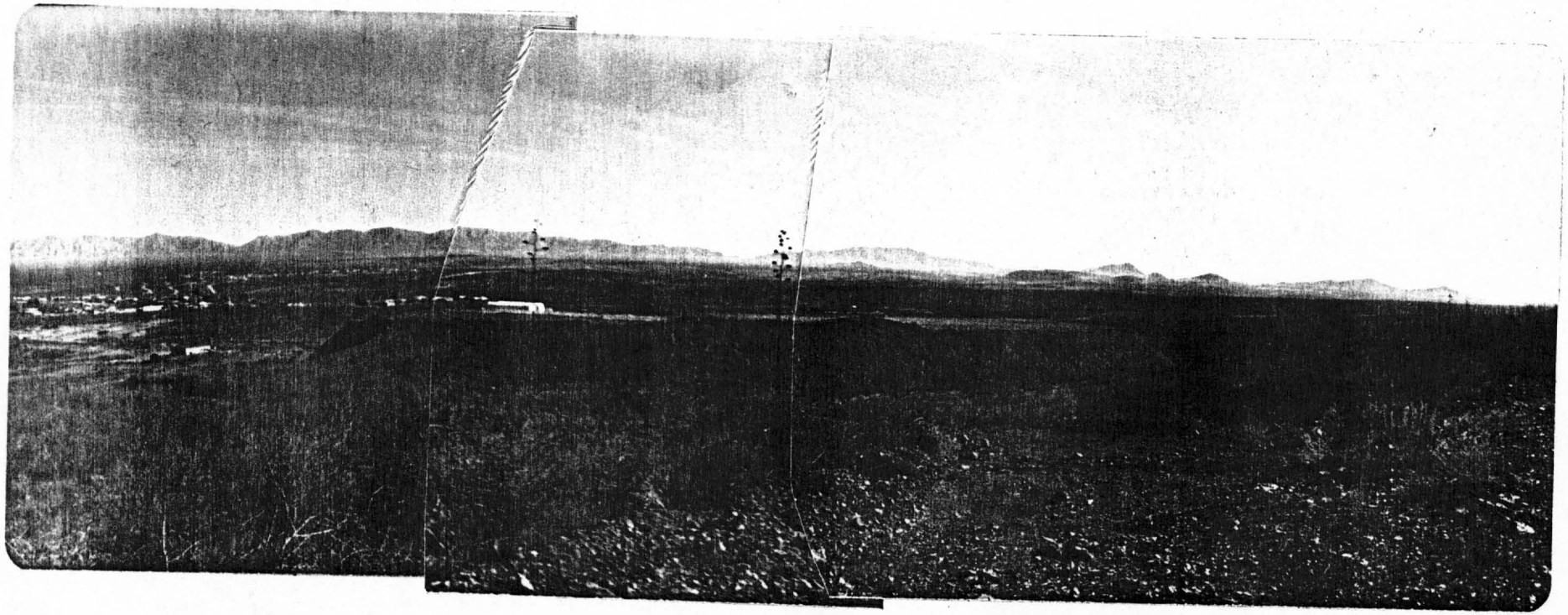
3. "Induced Percolation" has been tested on a reasonable scale and proved effective for increasing recovery.

The results upon which the above recommendation and conclusions were drawn follows in the enclosed report.

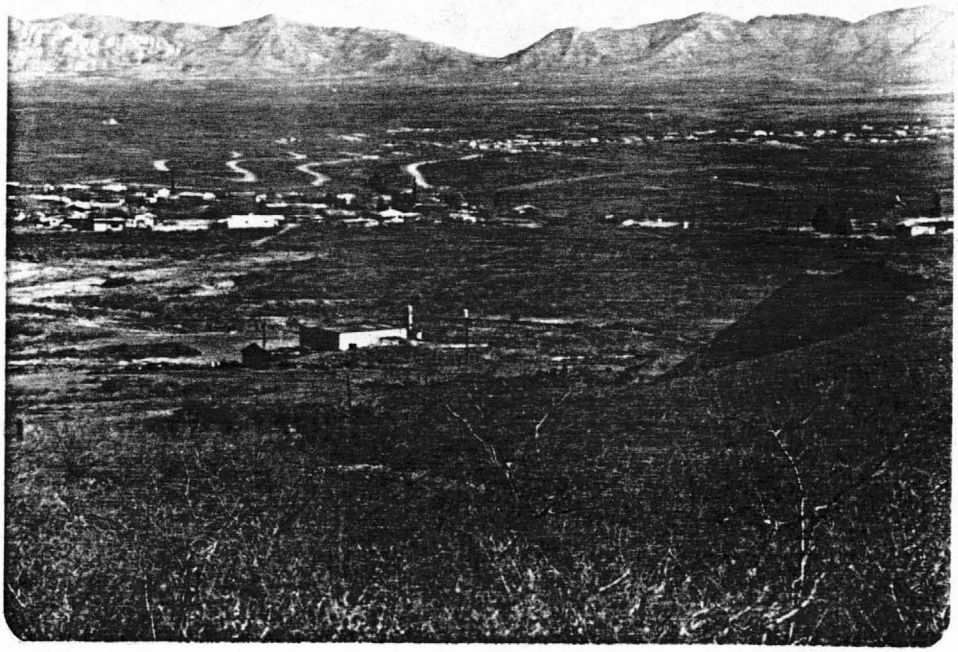
Sincerely yours,

Richard F. Hewlett

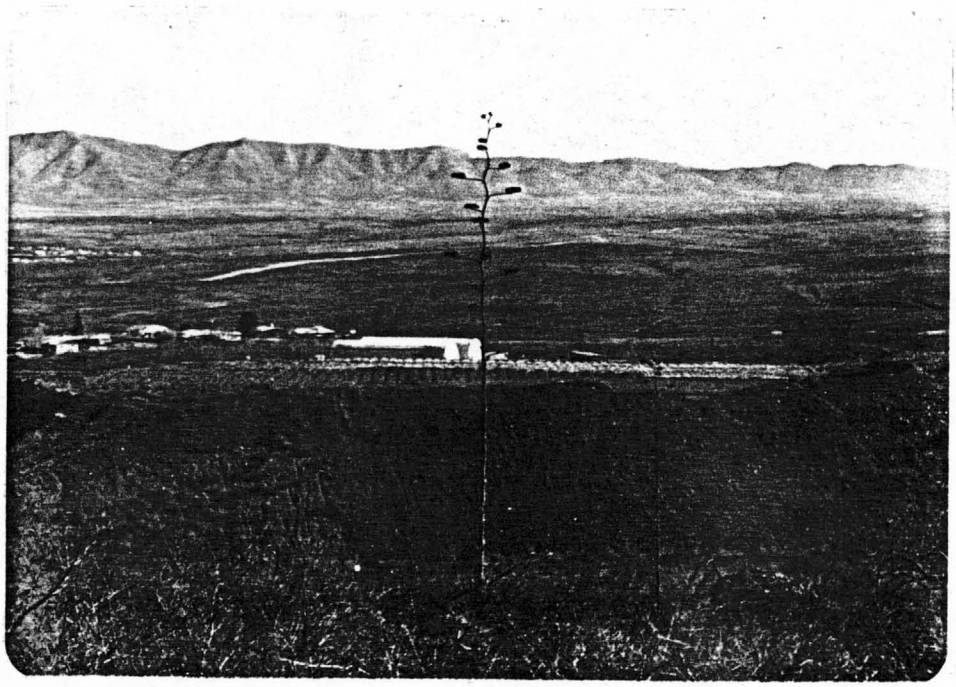
Richard F. Hewlett



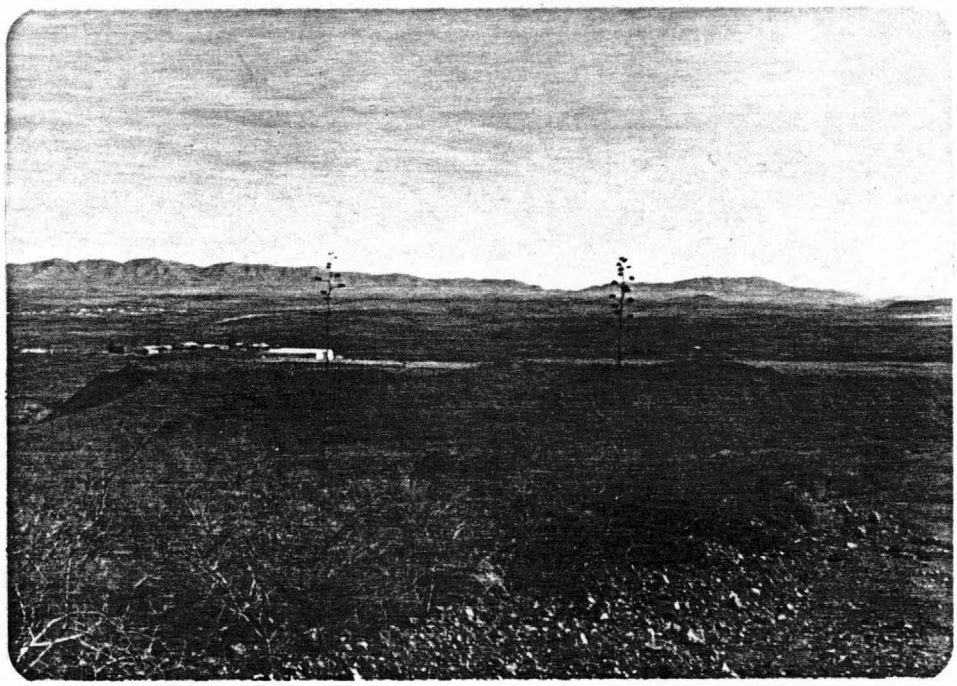
Tombstone Heap



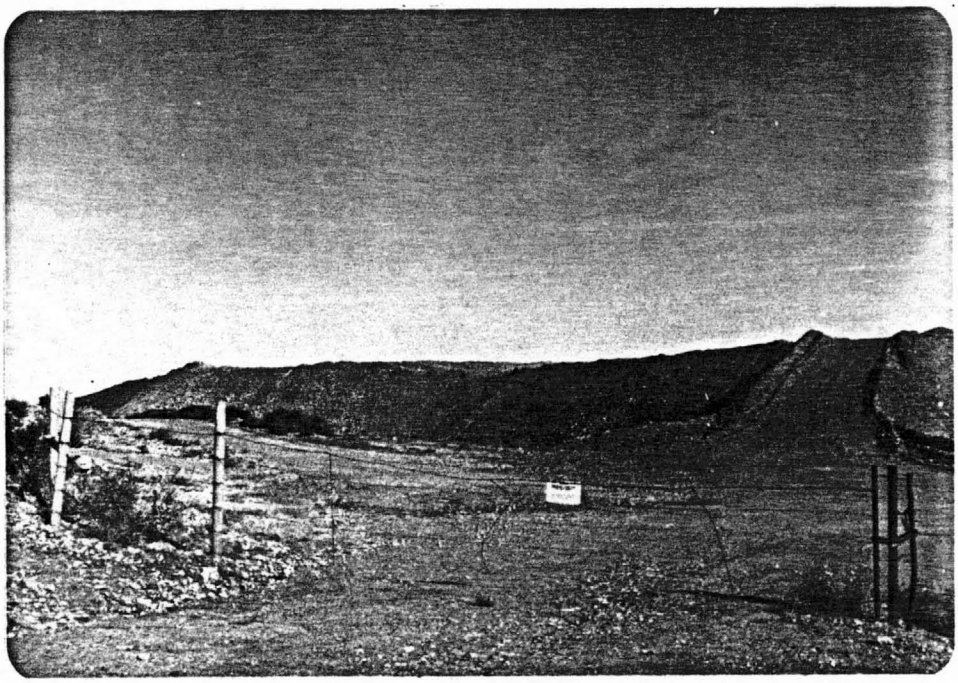
North Ramp and 71 Minerals Plant



North Ramp showing "ripped & dozed" section



North Ramp



South Ramp

Consultants in:
- Hydrometallurgical recovery
- Heap and conventional leaching
- Precious and base metals
- Uranium/Vanadium
- Tungsten
- Worldwide Mobilization

Division of
Southwestern Exploration Associates

4500 E. Speedway, Suite 14
Tucson, Arizona 85712
(602) 795-6097

Richard F. Hewlett
Vice President and General Manager
Chemical Engineer
Mining Engineer

S.E.A. Hydromet, Inc.

TOMBSTONE PROJECT

Analysis of Risk and Progress Report

Factors that previously have been proven to no longer be a risk factor are the following:

1. Water
2. Power
3. Labor
4. Supplies

Therefore, the remaining risk factors are:

1. Finalization of lease(signatures)
2. Governmental restrictions
3. Ore Reserves
4. Metallurgy
5. Metal Recovery

Recent results have proven the following:

1. Needs finalization-- only remaining risk.
2. No risk;sent letters and contacted all agencies.
3. No risk;ample ore reserves-constant confirmation.
4. Solvents:No risk;proven effective
   "IPS":No risk;good percolation and values
5. No risk

Summary of Results

A. Spraying Side Slopes

Hypo preg of 0.25 t.oz. Ag/ton;exactly what was predicted.

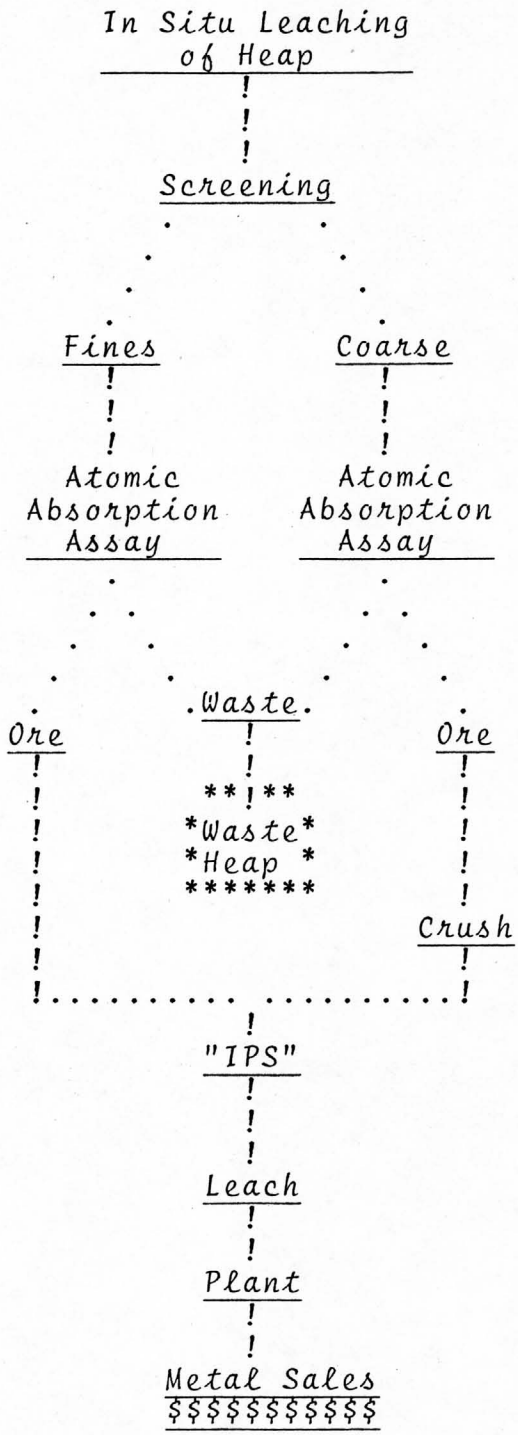
B. "IPS" for Tailings/dump/open-pit ore

80 tons recieved the "IPS" treatment and the initial(5 min.) preg was:

.015 Gold and .35 Silver

This is an excellant return and the percolation was very good. The results could not have been better.

TOMBSTONE PRODUCTION SUMMARY



BUDGET

Item	Est. Expenditure
15 KVA Transformer	$ 600
PVC fittings, elbow, tees	1,000
Sprinkler heads	200
Lab Atomic Absorption Std. Chemicals Work bench pH Meter Shaker Drying Oven Pulverizer Crusher Aceteylene Compressor(for oxygen) Pressure regulators	10,000
Padlocks (10@$4)	40
Chemicals	5,000
Management(Fees/expenses)	4,000
Labor	5,000
	$ 25,840

TOMBSTONE

Projected
Cash Flow

Following is my best estimate of cash flow for the next month:

Week	"IPS"	In-Situ
One	$10,000	$10,000
Two	15,000	25,000
Three	15,000	35,000
Four	15,000	50,000

The above is based on all previous test work, either lab or pilot scale.

Wire Transfer to the following:

S.E.A. HYDROMET - T.H.L. TRUST
4500 E. SPEEDWAY SUITE 14
TUCSON, ARIZONA 85712
PHONE AREA CODE (602) 795-6097

1013

91-1
1221 95

19

Pay to the order of $

Dollars

UNIVERSITY MEDICAL OFFICE/TUCSON
FIRST NATIONAL BANK OF ARIZONA

For

⑆122100011⑆ 957⑈06641⑈

Rocky Mountain Bank Note A

S.E.A. HYDROMET - T.H.L. TRUST
4500 E. SPEEDWAY SUITE 14
TUCSON, ARIZONA 85712
PHONE AREA CODE (602) 795-6097

1014

91-1
1221 95

19

Pay to the order of $

Dollars

UNIVERSITY MEDICAL OFFICE/TUCSON
FIRST NATIONAL BANK OF ARIZONA

For

⑆122100011⑆ 957⑈06641⑈

Rocky Mountain Bank Note A

S.E.A. HYDROMET - T.H.L. TRUST
4500 E. SPEEDWAY SUITE 14
TUCSON, ARIZONA 85712
PHONE AREA CODE (602) 795-6097

1015

91-1
1221 95

19

Pay to the order of $

Dollars

UNIVERSITY MEDICAL OFFICE/TUCSON
FIRST NATIONAL BANK OF ARIZONA

For

⑆122100011⑆ 957⑈06641⑈

Rocky Mountain Bank Note A

Consultants in:
• base & precious metals • uranium
• coal • geothermal • environment
• remote sensing • color aerial photography
• ›retation-image processing
Wo wide Mobilization

4500 E. Speedway, Suite 14
Tucson, Arizona 85712
(602) 795-6097

James A. Briscoe, President
Registered Professional
Geologist

Southwestern
Exploration Associates, Inc.

TOMBSTONE HEAP RE-PROCESSING BUDGET

Following is the initial capital investment required for re-processing the Tombstone Heap.

Item	Expenditure
Initial Property Payment	$ 6,000
Geological Report	3,000
Lease Expenses	3,000
Engineering	4,000
Power Hook-Up Deposit	3,500
Electrical Wiring	2,500
Pump Installation	3,000
West Side Water Line	2,500
Office Support	2,500
Pre-Production Royalty	7,500
Consulting Fees	5,000
Spray Lines/Manifolds	3,000
Directional Rainbirds	200
Preg Pond Lining	400
Pad Preparation	15,000
Laboratory	10,000
Building	15,000
Office	2,500
Recovery Plants	10,000
Reagent Tanks	3,000
Crushing - Working Capital	40,000
Chemicals	15,000
Insurance and Bond	5,000
Management	6,000
Labor	10,000
	$177,600

TOMBSTONE

Start-Up Chemicals

Name	Quantity	Unit Price	Total Price
SR-3 Resin (Ion-Exchange)	100 #	$ 6.50/#	$ 650
Lime-Paul Spur Processed(CaO)	20 tons	$14/ton	280
	Haul..	$25/hr	100
Sodium Hypochlorite (NaOCl-14% soln.)	5-55 gal.bbl.	$0.90/gal	248
Sodium cyanide (NaCN)	1000 #	$0.5615/#	562
Sodium sulfide (Na_2S)	400 #	$0.248/#	99
Zinc dust (Merrillite)	300 #	$0.662/#	199
Sodium thiosulfate ($Na_2S_2O_3 \cdot 5\ H_2O$)	300 #	$0.246/#	74
			$ 2,211

TOMBSTONE

Immediate Expenses

Category	Activity	Quote	Estimate
Power	APS Hook-Up(Deposit);		
	West Side Water Pump	$ 800	
	Old '71 Min. Plant	2,400	
	Office	50	
	Box & Meter Loop		$ 600
	Electrician		500
	Cable		1,000
	Switches & Elec. Misc.		500
	Pump pannel/Installation		1,000
Water Line	3-inch PVC;3,000 feet	2,250	
	Installation	300	
PVC Fittings	Tees, Manifolds, etc.		100
Sprays	Directional rainbirds		80
Preg Pond	Liner & labor		100
Lab	Chemicals		100
Building	Trailer(40X8')-2 months + $215		
	Monthly rent=$135	500	
Plant	4-50 GPM filter/recovery units		2,500
Tank	1350 gallon	350	
Chemicals	Start-Up solvents & reagents		2,432
Moving	Lab equipment & office		1,500
Labor	Leaching & crushing		2,000
Management	RF Hewlett, et.al. Sal/Expenses		4,000
Office	Reports & support		900
Misc.	Processing, freight, etc.		1,038
		6.650	18,350

Total= $25,000

DATE	PAID TO	CK #	PURPOSE	AMOUNT
3/8/79	Arizona Public Service	1	$50.00 deposit and $3,200.00 hook up for Skyline road residence	$ 3,250.00
3/8/79	Arizona State Land Dept. (P.O.4226)	2	Applications for mineral prospecting permits: T20S-R22E Sect.4,6,18 & 30 T20S-R23E Sect 7 T21S-R21E Sect 12 T21S-R22E Sect 4,5,7 & 8	250.00
3/9/79	Deposit			25,000.00
3/2/79	Richard Hewlett	3	Expense Advance	2,000.00
3/12/79	Ionac Chemical Company (P.O. 4224) Inv #100640	4	100 lbs. Ionac SR-3	689.00
3/13/79	Keenan Supply Inc. (P.O. 4256) Inv. #30153925	5	5 3" PVC Sch 40 Socket 45 Ells 1 3" PVC Sch 40 Socket TEE	19.66
3/13/79	Keenan Supply Inc. (P.O. 4251) Inv. #30153924	6	2,700 3 PVC Sch 40 plastic pipe 2 Gal PVC Primer 2 Gal PVC Cement	2,203.52
3/14/79	Willett Transport Equip. (P.O. 4267) Inv. #1229-2837	7	1 rental, 40' Storage van trailer for period of 3/15/79 - 4/15/79	499.00
3/14/79	Arizona State Land Dept.	8	1 application for mineral prospecting permit	25.00
		9	V O I D	
3/14/79	Arizona State Land Dept. (P.O. 4268)	10	19 Prospecting permit application fees: T20S-R22E Sect 4,5,36 T20S-R23E Sect 5,6,7,8,17,19,20,29,30,31,32 T21S-R22E Sect 1,2,3,9 T20S-R22W Sect 7	475.00

DATE	PAID TO	CK #	PURPOSE	AMOUNT
3/15/79	Gordon Coristine (P.O.4275)	11	Labor for moving lab equip. office, etc. Storage and maintenance of Jeep Wagonner	$ 200.00
3/15/79	McKesson Chemical Co. (P.O. 4272)	12	1 Drum 55 gallon 400# Na_2S 3 100# Drums Zinc Dust	358.07
3/15/79	Foxworth Killen Supply Co. (P.O.4276) Inv.#9419	13	Materials for electrical hook-up	448.30
3/15/79	Wally Dun (P.O. 4279)	14	C_2H_2 & O_2 Bottle deposit 7 days advance rental plus 1 day credit	75.00
3/15/79	Ed Pice (P.O.4278)	15	1 1/2 HP Centrifugal Pump 1 2 HP Centrifugal Pump	200.00
3/15/79	Thomas Colvin (P.O. 4277)	16	1 1350 Gallon Tank	350.00
3/15/79	Dusty Escapule	17	Salary Advance	500.00
3/16/79	U.S. Postmaster	18	Overnight delivery, receipt #B3306603	7.65
3/16/79	Mountain Bell	19	Deposit on phone in Tombstone	50.00
		20	V O I D	
3/16/79	Heflin - Harrington Industrial Plastics, Inc. (P.O. 4303) Inv. #3690	21	1 3x3x1 Tee Soc PVC-40 8 1 1/2" S.U. Ball Valves Soc PVC 3 3" 3-way Ball Valves Soc PVC 3 3" T.U. Ball Valve Soc PVC 1 1" T.U. Ball Valve Soc PVC 3 3" Tees Soc PVC - 40	TOTAL 1,214.07
3/16/79	Patio Pools (P.O.4319) Inv. #7984	22	4 EC - 65B Hayward filters	1,069.54
3/21/79	S.E.A. Hydromet	23	Payroll Advance	600.00
		24	V O I D	

DATE	PAID TO	CK #	PURPOSE		AMOUNT
3/22/79	Richard Hewlett	25	Travel Advance		$ 500.00
3/22/79	Keenan Supply (P.O. 4327) Inv.#30153927	26	140 3" Sch 40 PVC Soc. Couplings 1 3" Sch 40 PVC Slip X mip adpt 1 Freight Charge	TOTAL	162.39
3/22/79	Ernie Escapule (P.O. 4329) (Archie's Auto Parts, Inc.) Inv. #7939, 7930, 7938 Yellow Front	27	BDM OXY, valvoline oil, 3 filters, 2 G.E. bulbs, and other misc. auto parts Misc. Truck parts 1 weeks rent of two trucks	TOTAL	237.08
3/22/79	Foxworth-Killen Supply, Co.)P.O. 4328) Inv. #9589 & 9516	28	Misc.: pipe, galv. nipple, outs, hub, straps & log screws		20.94
		29	V O I D		
3/26/79	First National Bank (P.O. 4309)	30	Cashier's check for Mayflower Co. moving D. Hewlett from Sparks to Tombstone, Arizona		1,704.05
3/27/79	Richard Hewlett (P.O. 4350)	31	Deposit to account of AFH for cash for purchase of transmission to be installed in truck of George Jewett as compensation for rent of truck and purchase of chemicals used in Heap Leach processing		500.00
3/28/79	S.E.A. Hydromet	32	Payroll Advance		700.00
3/28/79	S.E.A. Hydromet	1001	Payroll Advance (first advance was not enough to cover payroll		700.00
3/28/79	Nellie Cashman Apts.	1002	Travel expense, April rent		188.70
3/30/79	S.E.A. Hydromet	1003	Payroll Advance		600.00
4/3/79	S.E.A. Hydromet	1004	Payroll Advance		1,500.00
4/4/79	Arizona State Land Dept. (P.O. 5229)	1005	Prospecting permit application fees		50.00

DATE	PAID TO	CK #	PURPOSE	AMOUNT
4/4/79	Arizona State Land Department (P.O. 5230)	1006	Prospecting permit application fees	$ 75.00
4/7/79	Richard T. Hewlett	1007	Gas reimbursement for March	309.47
4/7/79	Ernie Escapule (P.O. 5210)	1008	Reimbursement for: Texaco gas, elbos, repair kit, welding rod, pipe, oil filter, C_2H_2 OXY for welding/cutting, plastic tubing paint strip and ACY-OXY welding/cutting	137.44
			BALANCE	$3,141.12

GENERAL

TOMBSTONE

April 10, 1979

Following are a summary of the various activities and their status in the Tombstone Heap Leaching Operation.

Lease

The lease must be signed very soon, as last Friday I recieved another call from Bill Hight wanting a copy of the signature page and first page. He also wanted to know what the operation was to be called.

Also, the advanced minimum royalty of $7,500/month starts on May 1;it must be paid promptly.

Precious Metal Sales

Mr. Tom Schloss is working on who we will be buying our gold and silver. We expect this report soon.

Product-in-kind

Mr. Schloss is also working on this matter and will be reporting on this soon-coupled with a visit to Grand Island.

Insurance

Presently we have coverage through Jim Briscoe's policy that covers him and his staff on any property that they are working;exploration is covered with his policy. It provides for $500,000 bodily injury and $100,000 for property damage. I have increased the property damage portion to $500,000 for an annual fee of $153(see enclosed letter that follows).

71 Minerals Building

No progress can be made in occupying the old 71 Minerals building untill perhaps August.

Land Status

No money has been budgeted for lease payments to the State of Arizona. We could have leased portions of three sections, but $2/acre was required, or over $1900 plus a surity bond.
The proceedure that will be followed untill the leaching produces a cash flow is to keep applying for a permit and hope someone else does not get the leases.

RECEIVED MAR 24 1979

Tucson Realty & Trust Co.

Allan A. Dochtermann
Assistant Vice President

March 23, 1979

Mr. Richard Hewlitt
Southwestern Exploration Associates, Inc.
4500 East Speedway, Suite 14
Tucson, Arizona 85712

Dick:

To follow-up our phone conversation, the cost, on an annual basis, to increase the Property Damage portion of your General Liability Policy from the present limit of $100,000 to alternate limits of $250,000 or $500,000 would be $71.00 or $153.00 respectively. This, of course, is based on the salary estimations presently showing on the policy.

In addition, per Jim's letter of March 6, 1979 regarding a Performance Bond on your Tombstone properties, I explained to Chris that as far as we can tell after discussing this with several companies, a Performance Bond would not be the answer to your problems and indeed, a Performance Bond would not cover your liability. Instead a personal financial guarnaty is what they are in fact looking for.

Please let me know at your convenience the limits of liability you wish to carry.

Thanks,

Allan

Allan
Assistant Vice President
AAD:jo

0712

a-418 (2)

Governmental Requirements

Contacted concerning our heap leaching activities at Tombstone are the following:

1. Mr. R. E. Riley
   Sub District Mgr.
   M.S.H.A., DOL
   2721 No. Central Ave.
   Suite 900 Telephone: 261-3232
   Phoenix, AZ (85004)

2. Office of the State Mine Inspector
   7th Floor
   New Capital Building
   1700 W. Washington Telephone: 255-5971
   Phoenix, AZ (85007)

3. Ron Holly
   Education & Training
   M.S.H.A., DOL
   500 Date Street
   Boulder City, Telephone: 702-293-1033
   Nevada (89005)

Following is a letter to M.S.H.A.
Also enclosed is the correspondence concerning previous leaching with sodium thiosulfate. Following the Hypo correspondence are the M.S.H.A. requirements.

Power

The water-pump has been connected for some time, and recently APS connected our three-phase 440 V. service. We purchased a 3 KVA transformer(440 V. to 220). This is adaquate for our 2-2 horsepower pumps, but not any larger pumps. The wiring has been completed and all three boxes installed. The pumps use 220 V. single phase and have been operating since last Thursday.

Water Line

The water line was completed a week ago and the pond filled with water. The submersible pump develps a discharge of 50 gallons per minute-2800 feet from the West Side shaft. The pond was filled in 5 hours and this resulted in 15,000 gallons or 62.5 tons of water for spraying.

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4500 E. Speedway, Suite 14
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(602) 795-6097

Richard F. Hewlett
Vice President and General Manager
Chemical Engineer
Mining Engineer

S.E.A. Hydromet, Inc.

April 5, 1979

Mr. R. E. Riley
Sub District Mgr.
M.S.H.A., DOL
2721 No. Central Ave.
Suite 900
Phoenix, AZ (85004)

Dear Mr. Riley:

I called today and was directed to Mr. Tweety of your office. The purpose of my call is to inform your office of our intent to conduct heap leaching in the future at Tombstone, Arizona.

Presently, we are preparing to conduct tests on the same leaching facility that '71 Minerals used for many years. We would use the same pad and pond system and the same monitoring proceedure.

However, we will not be using cyanide. We will be testing on a very small scale the use of sodium thiosulfate($Na_2S_2O_3 \cdot 5H_2O$), which is also known as photographers Hypo. You may recall that we experimented on the use of hypo for leaching underground in 1976. Mr. William H. Shafer of the Bureau of Water Quality Control, Arizona Department of Health Services spent considerable time evaluating the toxic(or non-toxic) qualities of Hypo and finally came to the following conclusion:

> "Shafer said laboratory tests show a person would have to drink at one time 300 gallons of Hypo at the proposed concentration for the solution to be toxic".
>
> (See enclosed newspaper clipping).

However, we will not use as high a concentration of Hypo as reported in the Tombstone Epitaph. We will be using under one pound per ton of solution, or .05%.

I have been told that '71 Minerals "killed the cyanide" in the heap with sodium hypochlorite. As a precaution, we will add more sodium hypochlorite to be sure that we do not have any cyanide in our circulating solutions. I will check for cyanide content with the standard silver nitrate and potassium iodide titration. However, I realize that some cyanide will be detected by titration that will not be free or available cyanide; it is combined with copper and with zinc as zincates. If I have any doubts concerning the cyanide concentration, I will have a "free cyanide" determination made by the distillation method.

Our initial tests will be made with water in order to obtain a "water-solution balance" to make sure that the ponds and pad do not leak. I will inform your office of the results of our tests as soon as they are completed.

I have contacted Mr. Ron Holly's office concerning the required training our employee's will recieve. He will forward information concerning the training period and course of instruction.

I would appreciate receiving any other information or advise concerning various regulations related to heap leaching.

Thank you for your help in this matter.

Sincerely yours,

Richard F. Hewlett

Richard F. Hewlett

From The Town
Too Tough
To Die

The Tombstone Epitaph.

ol. XCVII No. 5 TOMBSTONE, ARIZONA, July 9, 1976

SIERRA METALS

RICHARD F. HEWLETT
President

NANNINI'S FINANCIAL CENTER
7110 NORTH ORACLE ROAD, SUITE 213
TUCSON, ARIZONA 85704
602 / 297-2566

July 8, 1976

Mr. William H. Shafer
Manager, Monitoring Section
Bureau of Water Quality Control
Arizona Department of Health Services
Phoenix, Arizona 85007

Dear Mr. Shafer,

The following is a progress report on our preparation for our "water balancing" test:

A. Our leaching test area is in the Upper Bisbee formation in interbedded limestone and shales (see figure 1). Our test zone in the Toughnut Incline is in the Blue Limestone member. This member was exposed on the surface and contained high grade zones within the dipping limestone member (see figure 2). The ore zone is on the flanks of an anticline and therefore dips about 35° to 45° (see figure 3). The proximity of the test zone in the folding is shown in figure 4. Notice the shale-limestone-novaculite interbedding. This is also seen in figure 5. Figure 5 shows the blue limestone area underlain by novaculite which is very competent.

The area of interest has been thoroughly mapped for geological fractures (see figure 6). Notice that no fractures have been found in our test area. Another interesting feature in the Toughnut area is that the last pulse of mineralization was calcite filling fractures.

B. Water Sampling: See the following report by Ed Speer.

c. Hypo-reaction products:
Samples of the hypo solution after leaching the gob have been submitted to the State Health Department as well as fresh water from the West Side shaft, that is presently flooding 300 vertical feet of gob (that is below the water table). Fresh water has also been furnished and has been circulated in dry gob for one week.

D. Water Leaching Test Area:
Figure 7 shows a generalized cross-section of the gob area and the lower test area. Our collection site has been selected at the end of a stope in a drift we have sealed (see figure 8).

E. Solution Collection System:
Two drifts that end have been selected as primary collections and overflow storage. These drifts are shown in figure 9. Water has been allowed to flood the drift to a depth of six inches and it is completely sealed with the combination of competent rock and fines (this is what is expected in the gob area). However, the collection and overflow ponds have been lined with bentonite, and then a plastic liner. The plastic liner is held back from the ribs by cardboard. A dam has been constructed to trap all the solutions further down the drift to the West Side in case both dams would fail, so that no solutions would get to the ground water table.

F. Test Area:
Figure 10 shows a plan map of the gob in the incline and our test area at the lower end. Our initial test area contains 715 tons of gob and drains through a raize directly into our collection pond. This is a closed system and we can monitor for any solution leaks under the gob area in our drifts on the 300 level. Use of dye would also indicate where we would be leaking and these fractures would be sealed. However, we have found no fractures that could cause any leaking. We are presently applying a very small amount of water to allow the fines to seal any microfractures that didn't show in the back.

G. "Water Balancing Monitor"
We have 3 flowmeters that will tightly control the water balance that is necessary to be sure of no leaks in the system (see figure 11). The flowmeters are positioned as follows:

1. Flow (volume) of fresh make-up water from West Side
2. Flow (volume) of spray solution (water)
3. Flow (volume) of solution (water) to the plant

Our "hypo" leaching test results show a relatively rapid leaching rate; so we will send the pregnant solution to the plant very soon after it flows into the collection pond, and this will accomplish two things:

1. Greatly reduce any danger of losing some pregnant hypo;

2. Greatly reduce the storage requirements underground.

Specifically for 715 tons of gob we will need:

1. 10 per cent in wetting the gob or 715 tons (this will remain in the gob for inventory);
2. One ton of water per 50 tons of gob or 14.3 tons to be circulated per day.

This is a total requirement of water of about 20 tons.

H. Eventual Hypo Leaching:
After the "water balance" has proven we are not losing any solutions, we would propose to add hypo as follows:

1. Initial circulation would be at a hypo concentration of one pound hypo per ton of water.
2. First returns will be assayed for gold and silver and the hypo concentration will be determined by titration. Additional hypo will be added to maintain one pound per ton until the gold and silver values are high enough to start sending to the plant.
3. Then the hypo strength will be gradually increased to determine if additional gold and silver is recorded. Our test results indicate that in about two weeks, all "hypo recoverable" gold and silver would be leached and at that time we would stop leaching in that area.

During the two weeks of hypo leaching, we will collect ground water samples on a weekly basis and submit the water for analysis through the Inspection Committee. After our leaching, two weeks, we will request another inspection to fully assess the hypo leaching underground.

Sincerely yours,

Richard F. Hewlett

Richard F. Hewlett

SIERRA METALS

RICHARD F. HEWLETT
President

NANNINI'S FINANCIAL CENTER
7110 NORTH ORACLE ROAD, SUITE 213
TUCSON, ARIZONA 85704
602 / 297-2566

Memo

To: R. F. Hewlett

Subject: Water sampling-Tombstone Area

From: Ed Speer

Date: June 2, 1976

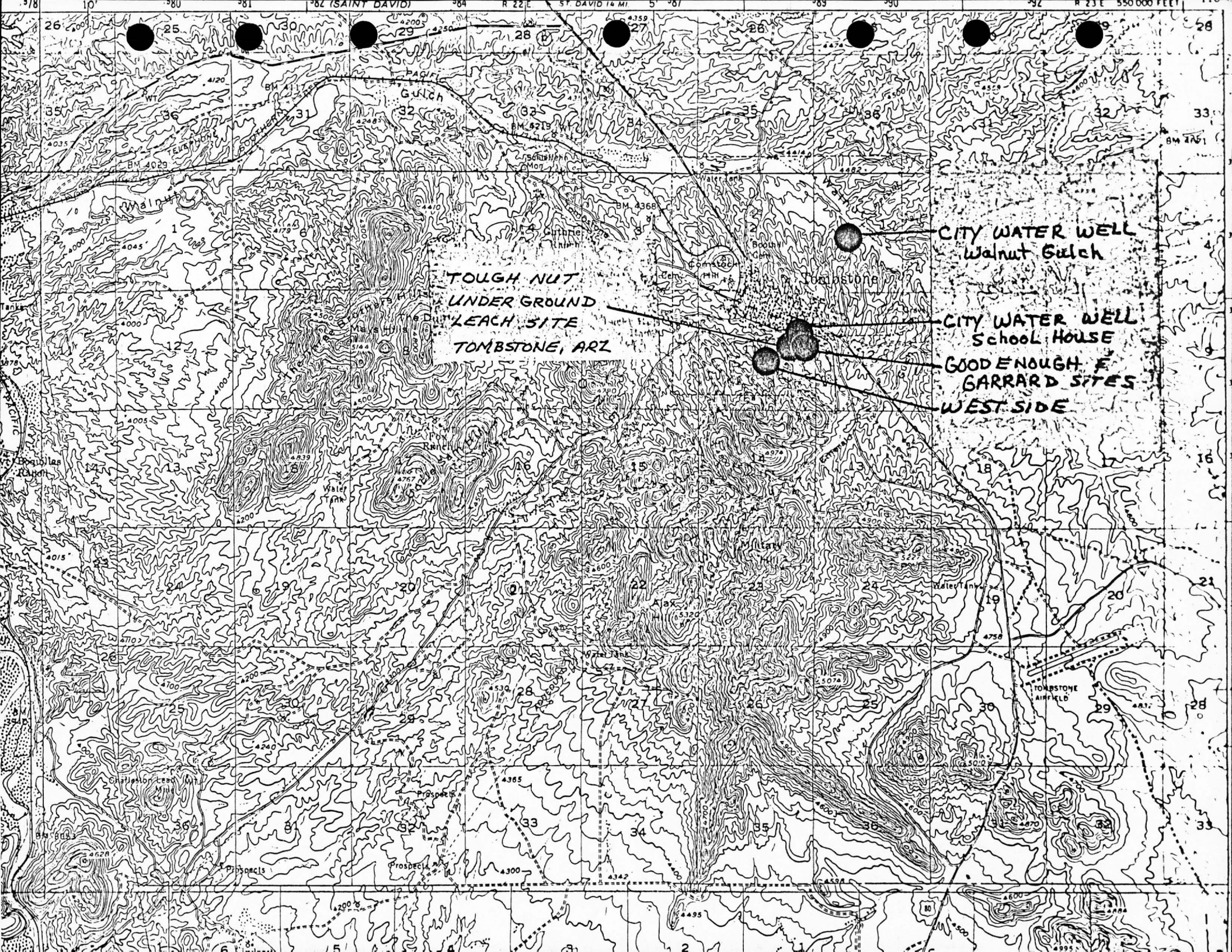
The enclosed map shows sites where water samples were collected by myself, Jerry Doherty, and Frank Mikan on June 1, 1976. The samples were submitted to the state Health Department in Phoenix by myself on June 2, 1976. The sample descriptions are as follows:

A. Tombstone City Water Well at school house
B. Tombstone City Water Well along Walnut Gulch
C. Water table at West Side Shaft
D. Water table in Girard Stope (Sulphuret incline)
E. Percher Water table on Good Enough incline

The city water well at the school house is approximately 1000 feet northeast of the leach site, while the well on Walnut Gulch is about 1 1/4 miles to the northeast. The sample from the westside shaft is from the ater table approximately 1500 feet southwest of the leach site. A sample was collected only 350-400 feet north of the leach site from a perched water table near the Good Enough incline. The last sample was collected from the water table in the Girard stope near the bottom of the Sulphuret incline and approximately 500 feet southeast of the leach site.

These sample sites should give adequate control for our water monitoring program. Fluorescein dye is on hand and will be used to trace any movement of water away from the leach site. Of course analysis of the water samples will establish any pollution caused by the leaching.

Ed Speer


TOUGH NUT
UNDER GROUND
LEACH SITE
TOMBSTONE, ARZ
CITY WATER WELL
Walnut Gulch
CITY WATER WELL
School House
GOODENOUGH &
GARRARD SITES
WEST SIDE
Tombstone
Comstock Hill
Boothill Cem
Guthrie Church
Mays Hills
Fox Ranch
Military Hill
Alax Hill
Water Tank
Prospects
Charleston Lead Mine
TOMBSTONE AIRFIELD
Walnut Gulch
PACIFIC
SOUTHERN
TELEPHONE
ST. DAVID 14 MI.
R 22 E
R 23 E
550 000 FEET

ARIZONA DEPARTMENT OF HEALTH SERVICES

Division of Environmental Health Services

UL H. CASTRO, Governor
SUZANNE DANDOY, M.D., M.P.H., Director

May 4, 1976

Mr. Bert C. Romero
State Mine Inspector
705 West Wing
State Capitol Building
Phoenix, AZ 85007

RE: 71 Minerals - underground leaching operations - Toughnut Mine

Dear Mr. Romero:

The Bureau of Water Quality Control has reviewed the proposal for the underground application of sodium thiosulfate, hypo, or sodium hyposulfite and finds the following:

1. That sodium thiosulfate at the proposed concentrations or as might reach a groundwater supply is not considered to be toxic in and of itself;

2. That there is a significant difference in the assessment of potential groundwater pollution as made by 71 Minerals and this Bureau. 71 Minerals asserts that pollution potential is very low and that water recovery tests will verify this position. The nature of sodium thiosulfate and the selectivity of its action are also cited as reasons for low pollution potential. The Bureau of Water Quality Control asserts that the proposed operation is very risky and that potential for groundwater pollution is high. Extensive flooding of existing mining shafts coupled with highly fractured geologic strata make it almost certain that any leakage from the leaching operation will have direct access to the groundwater supply. The Bureau concedes that water recovery testing may indicate that leaching operations can be successful if properly supervised;

5.

3. That the Bureau of Water Quality Control does not have adequate staff to supervise the leaching operations to insure that contamination of groundwater supplies can not occur;

3. 4. That contamination of the groundwater supply will more likely be the result of reaction products rather than from sodium thiosulfate in its original form;

3. 5. That the quality of the sodium thiosulfate solution and water after passing through the leaching zone are not known;

4. 6. That it is not possible to estimate the impact on groundwater supplies with available existing data;

4. 7. That water levels in the Toughnut mine, Westside mine, Silverthread mine, Contention mine, and the two wells owned by the City of Tombstone should be identified using a common bench mark;

8. That the strike and dip of the major fracture zones in the leaching area should be identified;

4. 9. That a water quality monitoring program is needed to identify existing quality and trends. A method to detect movement of potential pollutants prior to reaching the water table should be part of the monitoring system;

5, 10. That adequate records need to be maintained to determine recovery of all solutions pumped;

11. That the project as proposed may be in violation of U. S. Public Law 93-523, the "Safe Drinking Water Act";

12. That the State of Arizona has no groundwater quality standards that apply;

13. That an adequate environmental assessment has not been completed. That such an assessment should evaluate impact on groundwater supplies and the availability of other water supplies for Tombstone. That there is no authority to require such an impact statement;

14. That the City of Tombstone is highly dependent upon existing groundwater supplies;

15. That the City of Tombstone is highly concerned with industrial development within and adjacent to the City, and should be made aware of any development with a potential impact on the City water supply.

16. That the city planning guide recognizes the need for development that complements " . . . both adjacent activities and the overall pattern of community development";

17. That the proposed leaching process may be unique and a desirable non-toxic leaching process such that it could become an asset to the City of Tombstone;

18. That large-scale testing on a surface dump would be desirable prior to actual underground leaching;

Based on these findings, the Bureau of Water Quality Control recommends that 71 Minerals be allowed to conduct a water recovery test subject to the following conditions:

1. That prior to the actual water recovery test, a surface test will be conducted using water and a sodium thiosulfate solution (equivalent to 7 pounds sodium thiosulfate per ton of water) as leaching solutions. They should be applied to materials representative of the underground leaching areas and they should be applied in such a manner as to be representative of both application rates and contact times. Samples of the product solutions should be submitted to the State Laboratory for examination;

2. That prior to the water recovery test, an underground inspection of the leaching areas should be conducted, if possible, by representatives of the Bureau of Water Quality Control, the Arizona Water Commission, the State Mine Inspector's office, the Arizona Bureau of Mines, the Cochise County Health Department, representatives of the City of Tombstone and representatives of the SouthEastern Arizona Governments Organization, the designated water quality planning agency;

3. That prior to the water recovery test, a public meeting is to be held to discuss the process and evaluate potential hazards to the water supply. Such a meeting should be conducted by the Bureau of Water Quality Control;

4. That prior to the water recovery test, 71 Minerals should submit plans and specifications satisfactory to the Bureau of Water Quality Control to insure that the pumping system is adequate, that water or solution from any rupture in the piping system will be contained to prevent leakage to any shaft that might intercept the groundwater directly or indirectly, and that there is a system for positive metering of all solutions applied and recovered;

5. That the actual water recovery test be observed by representatives of all concerned parties;

6. That adequate records be kept of all solutions applied and recovered;

7. That results of all water testing be reviewed prior to approval to apply any chemical agents such as sodium thiosulfate;

8. That water samples of recovered water be collected and submitted to the Arizona State Laboratory for analyses;

9. That a monitoring program satisfactory to the Bureau of Water Quality Control be maintained by 71 Minerals with results to the Bureau as may be specified;

10. That any approval for the water recovery test does not constitute approval for the application of any chemical leaching agent;

11. That approval by the Bureau of Water Quality Control to apply a chemical leaching agent will in part be dependent upon but not limited to the satisfactory completion of the test conditions and the satisfactory assessment of problems associated with the proposed leaching operation.

Your concern and action in this matter is appreciated. Should you have any questions, please feel free to contact this office.

Sincerely,

Wm. H. Shafer, Jr., P.E.
Manager, Monitoring Section
Bureau of Water Quality Control

WHS:mh
cc: 71 Minerals - Mr. Hewlett
Venture Mining Co., Ltd. - Mr. Darrah
Arizona Water Commission - Mr. Briggs
Arizona Bureau of Mines - Mr. Rabb
Arizona Land Department - Mr. Allen
Cochise County Health Department
City of Tombstone
SEAGO
U. S. Geological Survey - Mr. Babcock
EPA

ARIZONA DEPARTMENT OF HEALTH SERVICES

Division of Environmental Health Services

...L H. CASTRO, Governor
SUZANNE DANDOY, M.D., M.P.H., Director

July 29, 1976

Mr. Richard F. Hewlett
President
Sierra Metals
Nannini's Financial Center
7110 North Oracle Road, Suite 213
Tucson, AZ 85704

Dear Mr. Hewlett:

Approval to conduct water balance tests on 715 tons of gob located in the Toughnut Incline at the 300-foot level is hereby granted, subject to the following conditions:

1. Please submit a water balance or accounting procedure prior to water balance test. This should include any forms to be used and a sample of calculations to be used. It might be helpful to show the balance on the water applied to date.

2. Results of the water test must be reviewed prior to actual leaching, using hypo-solution.

3. This approval for water testing does not imply approval for "hypo" leaching.

Mr. Rabb of the Bureau of Mines and Mr. Lindeman of our office, plan to observe the water tests while under way, sometime during the week, beginning August 2. 10:00 a.m. 8/4/76 Methods for calculating the water balance should be available to them at that time. This is in addition to the forms and calculations to be sent to our Phoenix office.

Your suggestion that operations be reviewed by an outside consultant is reasonable. Any professional, registered with the State Board of Technical Registration would likely be acceptable.

Your continued cooperation in this matter is appreciated.

Sincerely,

William H. Shafer, Assist. Chief
Technical Services & Support
Bureau of Water Quality Control

WHS:cp

cc: Cochise County Health Department
City of Tombstone
State Mine Inspector, Mr. Romero
Bureau of Mines, Mr. Rabb
Arizona Water Commission, Mr. Osborn
Southern Regional Office, Tucson
EPA, Region IX, Virginia Hammer

SURFACE MINER TRAINING PROGRAM

Mine Safety and Health Administration
Phoenix, Arizona, Training Center

December 21, 1978

United States Department of Labor
MSHA
Mine Safety and Health Administration

Preface

The following program has been designed for operators in surface operations to meet the requirements of Part 48, Subpart B, Health and Safety Training and Retraining of Miners, as published in the Federal Register, October 13, 1978.

The materials are general in nature and attempt to cover concepts that are common to most surface operations. In each module or unit, suggested spots for insertion of material directly related to specific operations have been included. It is important that the safety policy and procedures developed for specific operations be included at these points.

Visuals including 35 mm slides and 16 mm films have been suggested in certain areas. These materials and visuals will be available on a loan basis and may be reproduced by any operator.

When used in its entirety, including material pertinent to specific operations, the program is sufficient to meet the following requirements of Section 48.23(a):

1. Training new miners.
2. Training newly employed, experienced miners.
3. Annual refresher training.

The chart included relates the modules to specific courses required by the regulations. In most cases, modules will overlap one or more required courses. The anticipated time for each module will vary according to the needs of the property; however, it is assumed the entire program would include between twelve and sixteen hours of required training.

If the eight-hour/sixteen-hour option is requested and approved as described in Section 48.25(a), programs with asterisks are required to be given in the first eight hours prior to the miner reporting for work. The remaining modules could be given during the next sixty days to meet the requirements.

Each module contains a list of goals or objectives that may be used to meet requirements under various sections of the regulations. By selecting goals you wish to achieve, each module can be tailored to meet the needs of any of the three programs mentioned above.

Materials are also included covering the task training program required under Part 48.23(a). These materials are sample materials only and are designed to be guidelines for you in the development of your task training program.

The goals listed in the modules are the major subjects found in the training program. These goals can be used "as is" or changed to facilitate the needs of a particular operation. These goals are put together in a general format to assist the instructor in designing programs that fit the needs of a particular plant or operation.

Module Course Relationships

REQUIRED TRAINING / MSHA MODULES	Statutory Rights of Miners	Mobile Equipment	Working Around Mobile Equipment	Stationary Equipment--Protective Equipment	Slips and Falls	Communications	Lifting	Health (Hygiene)	Noise	Fire Extinguishers	Highwalls	Electrical Lock-Out and Grounding (contact accidents)	Explosives
(1) Instruction in the statutory rights of miners and their representatives under the Act; authority and responsibility of supervisors.	X												
(2) Self-rescue and respiratory devices.		X	X	X				X					
(3) Transportation controls and communication systems.		X	X			X							
(4) Introduction to work environment.**		X	X	X		X		X	X		X	X	X
(5) Escape and emergency evacuation plans; firewarning and firefighting.						X				X			
(6) Ground control; working in areas of highwalls, water hazards, pits and spoil banks; illumination and night work.											X		
(7) Health.								X	X		X		
(8) Hazard recognition.**		X	X	X	X		X	X	X		X	X	X
(9) Electrical hazards.												X	
(10) First aid.													
(11) Explosives.						X							X
(12) Health and safety aspects of the tasks to which the new miner will be assigned.**		X	X	X	X	X	X	X	X	X	X	X	X

**Must be covered in the first eight hours of training.

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To the Instructor

The materials in this package have been developed by a committee composed of members of various industry associations, corporate safety and training representatives, and MSHA personnel. These materials are designed on an open principle so that they may be used in large groups consisting of more than one company, or at small operations with individuals. Visuals have been keyed to specific areas and add to the presentation; however, the use of the visuals is not imperative to the success of the class.

If the materials are used in large groups consisting of more than one property, each property attending must fill in the specific information required when the trainee reports for duty.

In order to use the materials effectively, it will be necessary to read through the entire package and determine what you will be required to add to the program regarding your property. The materials may then be separated and used in modular form in any order needed on your property.

Visuals to accompany the materials can be borrowed from the Training Center and copied for your own use. If you would prefer using slides of your own operations, the program may prove more effective.

In some areas, handouts would add to the effectiveness of the materials. Handouts for your lock-out procedures, emergency procedures, and preshift checkoff sheets for equipment operators may prove to be a valuable addition.

The materials have been geared as much as possible to active student participation. The questions asked are meant to be answered by the trainees if at all possible. The more the trainee participates in the program, the better the change for retention of the materials.

Evaluation devices have been included in each module to help the instructor determine if he is getting the points across. These evaluation devices were not meant to be for pass/fail on the part of the trainee. Use the evaluations in light of how to improve the presentation.

The quality of the training will be determined to a great extent on the effort put forth by you, the trainer. Your enthusiasm and effort will "pay off" in more safety minded employees and, hopefully, a reduction in the accident frequency.

Goals and Objectives by Module

1. Statutory Rights of Miners--48.25(b)(1)

   The trainee will:
   a. Read and ask questions on MSHA statutory rights brochure.
   b. Listen to explanation and ask any questions regarding the authority and responsibility of supervisors.
   c. Read and ask any questions he might have about safety rules.
   d. Follow proper procedure to report hazards.

2. Mobile Equipment--48.25(b)(2),(3),(4),(8),(12)

   The trainee will:
   a. Make proper preoperational checks of equipment.
      (1) Know what to do if the vehicle is not safe for operation.
      (2) Know who to report to.
      (3) Know how and what to check for safe operation.
   b. Know traffic patterns and traffic rules on the property.
   c. Understand basic safety operations for operating equipment he will be required to use.

3. Working Around Mobile Equipment--48.25(b)(2),(3),(4),(8),(12)

   The trainee will:
   a. Be familiar with areas where you come in contact with vehicles and know proper walkways, travelways, and traffic patterns.
   b. Know what to do in order to keep in a driver's line of visibility.
   c. Be familiar with hand, light, and audible signals.

4. Stationary Equipment--Protective Equipment--48.25(b)(2),(4),(8),(12)

   The trainee will:
   a. Be aware of inherent dangers of stationary equipment.
   b. Know and understand machine guarding.
   c. Know the different types of protective equipment available and when to use them.

5. Slips and Falls--48.25(b)(8),(12)

   The trainee will:
   a. Identify the causes of slips and falls on the same level.
   b. Identify means of eliminating potential hazards causing slips and falls.
   c. Identify the causes of slips and falls on lower level falls.
   d. Identify methods of eliminating potential hazards from lower level falls.
   e. Know correct methods for climbing and placing ladders.

6. Communications--48.25(b)(3),(4),(5),(11),(12)

The trainee will:
a. Know various types of one-way communications. Know the types used on his property and what they are used for.
b. Know the types of two-way communications. Know and demonstrate types used on his property and know where they are located on the property.
c. Know what communication systems to use in case of emergency situation.

7. Lifting--48.25(b)(8),(12)

The trainee will:
a. Know the cause of back ailments.
b. Know basic methods of transferring material.
c. Identify points to remember before moving a load.
d. Know and demonstrate the six steps in correct lifting.
e. Be aware of ways to prevent back strain.

8. Health (Hygiene)--48.25(b)(2),(4),(7),(8),(12)

The trainee will:
a. Know that monitoring devices are used to measure any health problems that could occur on the property.
b. Be aware of the type of respirators used on the property. Know how to use, when to use, type to use, and how to keep in proper operating procedures.

9. Noise--48.25(b)(4),(7),(8),(12)

The trainee will:
a. Be aware that noise over a long exposure time can be detrimental to hearing.
b. Know the types of protective equipment that are available; know when and how to use.
c. In areas where sound suppression equipment is used, make sure you know when it is working effectively.

10. Fire Extinguishers--48.25(b)(5),(12)

The trainee will:
a. Know where fire extinguishers and alarms are located on property.
b. Know four basic types of fires.
c. Know four basic types of fire extinguishers and the correct selection and use of each.

11. Highwalls--48.25(b)(4),(6),(7),(8),(12)

The trainee will:
a. Know what a highwall is.

b. Know inherent dangers around highwalls.
c. Know when safety harnesses and lifelines are required on the property.
d. Know the procedures for reporting any unsafe condition(s) that might be found when working around highwalls.

12. Electrical Lockout and Grounding (contact accidents)--48.25(b)(4),(8),(9),(12)

The trainee will:
a. Identify contact hazards located on the property.
b. Be able to recognize fire hazards.
c. Be able to recognize electrical hazards.
d. Know what electrical lockout is and company procedures for a lockout system.
e. Know housekeeping procedures that lead to unsafe conditions.
f. Know what grounding is and how to insure equipment is grounded correctly.

13. Explosives--48.25(b)(4),(8),(11),(12)

The trainee will:
a. Identify various types of warning devices.
b. Be able to list different safety steps to observe when working around storage areas.
c. Know specific blasting regulations on his property.
d. Be able to identify vehicles that move explosives.

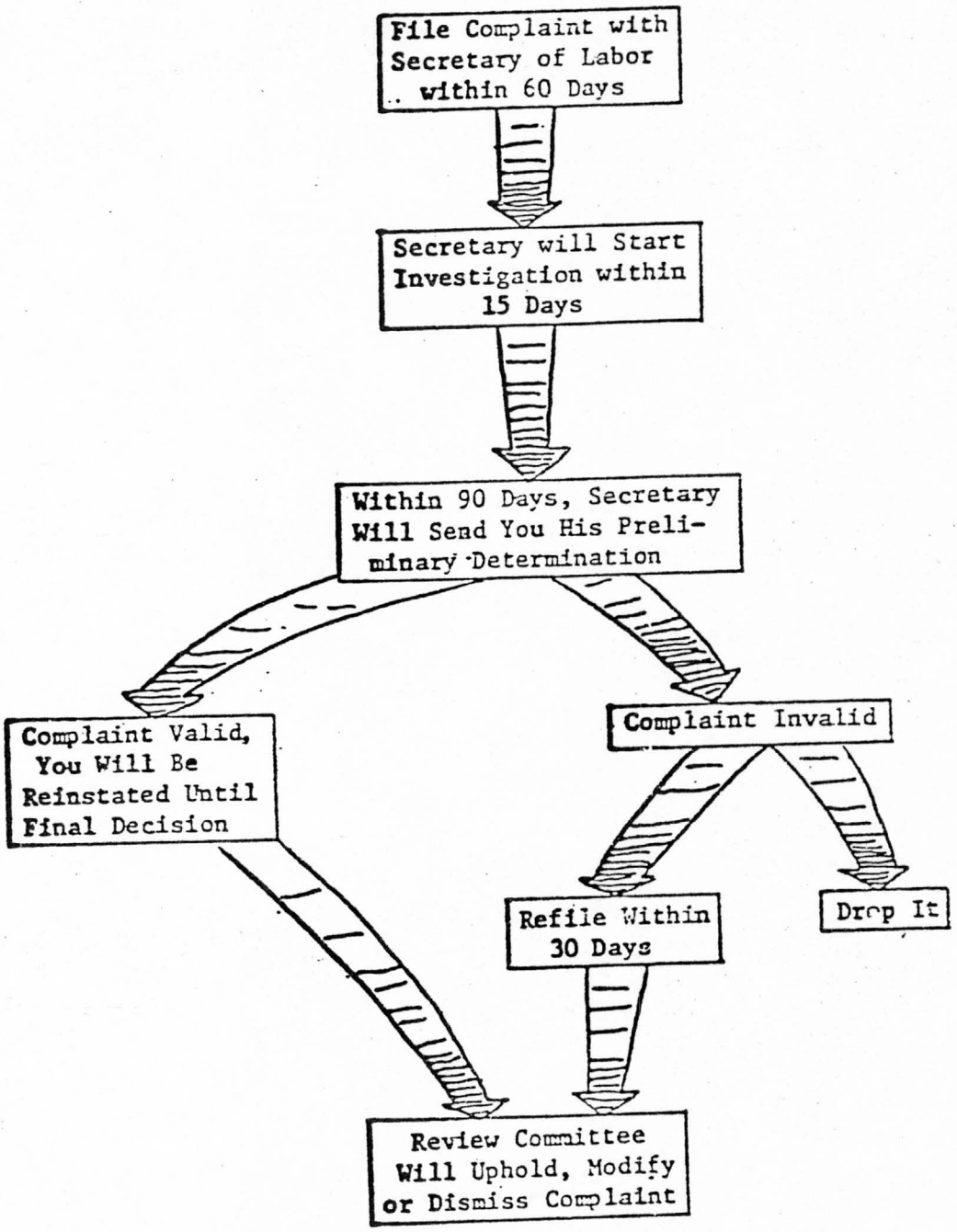
	Instructor	Media Material	Student
	FMSHA 77 established that all miners have specific rights dealing with their health and safety at the work sites. These rights have been published as rules in the Federal Register. These rules were designed to protect you, the miner.	Excerpts from rules, CFR 30, as published in Federal Register, March 3, 1978 (Handout of Rights)	Listen and watch.
	Most importantly, the Act states that the operator must furnish a safe and healthful working place and establish a program to provide that the working place remain as safe and healthful as possible.	VISUAL--Digest of statement, re: safe working place.	Listen and watch.
	The Act also suggests that you, the employee, have the responsibility of following the safety and health procedures designed by the operator to protect you while you are at work. The employer or operator has the responsibility of instructing you in all safety and health rules and procedures established for your working place.	VISUAL--Do It Right	Listen and watch.
	The key to safety is close cooperation between you and your employer safety and health procedures are established and followed at all times.	VISUAL--YOU + BOSS -- Safety	Listen and watch.
	In general, your rights as defined in the published standards fall into general areas. (1) Right to a safe working place. (2) Reporting of unsafe conditions. (3) Rights to proper training for safety and health procedures. (4) Rights to accompany inspectors. (5) Discrimination because of exercising of rights under the Act.	VISUAL--General Rights of Miners	Listen and watch.

	Instructor	Media Material	Student
	We have already mentioned the employer's responsibility of furnishing a safe and healthful work place and your responsibility to follow established procedures for health and safety.		
	Right now, you are engaged in the second mandated right--training for health and safety. Your employer has the responsibility of providing you basic health and safety training. This training must include specific courses related to mineral operations and follow a training program approved by MSHA for this purpose. In addition to the mandated training, the operator must also train you in the safety aspects of tasks that you will perform while working on the property. He must also set up 8 hours of annual refresher training for all employees as submitted in the approved training plan.	VISUAL--Training You Will Receive: (1) Entry (2) Refresher (3) Task	Listen and take notes.
	The training plan the operator uses was posted for 2 weeks so the employees or employee representatives could examine it and make written comments prior to its submission for approval. *Instructor Note: Signify how it was done on your property.*		
	When you complete your training, the operator will keep a record of the training and furnish you with a copy of this record. If you terminate your employment with your employer, you are entitled to a copy of all training that you have received.	VISUAL--Upon termination--copy of training records.	
	The second general area of rights regards reporting procedures for unsafe conditions or procedures in your working place. Your employer will inform you of the proper		

	Instructor	Media Material	Student
	reporting procedures established on the property; however, usually it involves reporting any hazard or unsafe condition immediately to your foreman or immediate supervisor. He, then, has the responsibility of determing a satisfactory solution to the problem. If the solution of the immediate supervisor is not satisfactory, the safety director or safety department should be notified. If the solution is not satisfactory, your union representative or designated representative may be of help to you. They will follow a predetermined procedure to arrive at a solution to the problem.	VISUAL--Reporting Procedures: (1) Immediate Supervisor (2) Safety Department (3) Union or miner representative (4) MSHA	
7	You also have the right to call MSHA to ask for help in the problem. The MSHA inspection office in your area is at telephone _____. The MSHA people will assist you, answer any question, and come to the property, if necessary, to determine the extent of the problem and specific solutions that may be needed. The next general area of rights involves discrimination. If you report a hazard or unsafe condition or in any other way file for action in the area of safety or health, the employer may not discriminate against you for your activities. These activities include: (1) Filing a complaint because of --alleged dangers --safety or health violations	(Hand out sheet with reporting procedures.)	Fill out steps of reporting procedures.

	Instructor	Media Material	Student
	--medical evaluations (under 101 of Act) --proceedings relating to the Act (pending, testifying)		List on hand out sheet.
	If you feel you have been discriminated against because of health and safety involvement, a procedure for filing discrimination charges has been determined under Section 105(c) of 1977 Mandatory Act. *Instructor Note: Procedures for filing discrimination charges have been included in this package.*	Copy of procedures for discrimination.	
8	The next general area of rights include the right to accompany MSHA inspectors on regular and spot inspections. Miners are entitled to have a designated representative accompany the inspector on all regular and spot inspections.		

Procedure for Filing Discrimination Charges



QUICK CHECK--STATUTORY RIGHTS OF MINERS

1. My rights under the Act include (check all that apply):

   _____ a. Safe and healthful working place.

   _____ b. Reporting unsafe conditions.

   _____ c. Suggestion box and awards.

   _____ d. Accompainment of inspectors.

   _____ e. Training in health and safety.

   _____ f. Company financial report.

2. Reporting procedures include the first step of reporting hazardous or unsafe conditions or procedures to (check one):

   _____ a. Immediate supervisor.

   _____ b. MSHA.

   _____ c. President of company.

3. During inspections, the inspector may be accompanied by (check one):

   _____ a. Myself.

   _____ b. Designated representative of miners.

   _____ c. A disinterested third party.

4. The operator must have a training program approved by MSHA (check true or false).

   _____ True _____ False

5. If I don't understand any safety procedures or rules, (my immediate supervisor), (a MSHA inspector) will answer any questions I may have (circle correct answer).

	Instructor	Media Material	Student
	Mobile Equipment		
	Many of you will be operating vehicles as part of your assigned duties. Remember, as an operator your responsibility for safety doubles. You will be controlling a vehicle that could injure not only yourself but others as well.	Hand out quick check. Have class answer question No. 1. Go over course. After film, have class answer question No. 2. Slides of different types of mobile equipment.	Listen.
	In the operation of these vehicles, you need to be constantly alert to things going on around you. In all cases, if you are not sure that it's safe to operate the vehicle, check out the situation with your foreman. Don't trust luck--know what you're doing.		Listen and look.
	Your company will train you in the proper procedures for operating vehicles you will be using on the job. However, here are a few general rules regarding vehicle operation that if followed will insure that you don't injure yourself or somebody else.		Listen.
	(1) If you are not familiar with a piece of equipment, learn it before you use it. (2) Know the limits of the vehicle you are operating and what it was meant to do. (3) Visually inspect the vehicle before you try to operate it (use operator check list). (4) Use the proper method of mounting the machine. Don't jump on or off.	VISUAL--I Can Drive Anything (1) Men in bucket. (2) Lifting too much too high. (slides)	Listen and watch. Listen, watch, and discuss.

	Instructor	Media Material	Student
	(5) Check out all controls and safety devices before moving. If you find that something is wrong with the machine, report it to your foreman immediately. He will assist you in finding a solution. (6) Use seatbelts where they are included in the procedures. (7) Check area around machine before moving. (8) Move with caution at all times. (9) Observe all speed limits. (10) Shift down when going down a grade (use same gear needed to go up). (11) Be aware of other vehicles and workers in your work area. (12) Follow the prescribed traffic patterns. (13) Park only in designated areas. (14) Never get off machine without shutting it down. (15) When dismounting, use handrails and steps provided. (16) Follow any blocking procedures used when parking. (17) Riders only where authorized.	(Visuals of 16 items listed could be used.)	
	This film will repeat many of the things we have already mentioned in class. On the paper provided, mark down anything we have mentioned in the right hand column and anything we missed and they mentioned in the left hand column. We will discuss them at the end of the film.	Show film, "Color of Danger" *Instructor Note: What did you find in viewing the film?*	Watch film. Make out lists. Go over the lists.

QUICK CHECK---MOBILE EQUIPMENT

1. List any safety rules you can think of when operating mobile equipment. _____

_____

_____

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2. List any other safety procedures learned from discussion or film. (To be answered after film)

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	Instructor	Media Material	Student
	Working Around Mobile Equipment.		
	Moving vehicles are used in all processing areas within the mineral industry. Part of your responsibility for your own safety is to be aware of vehicles that operate on your property, traffic patterns they follow, and means of keeping yourself clear of any moving vehicle.	VISUAL--Don't get yourself in this position. Know: (1) vehicles (2) traffic patterns (3) walkways	Listen and watch.
	In places where you come in contact with vehicles such as: (1) loading docks (2) cleanup work (3) dump points (4) haulage ways	Rail and truck Forklifts Front-end loaders Bobcats Hoppers Dump points Storage piles	Listen, watch, and discuss.
	(Ask what vehicles they may be working around.) All operators have been trained in the operation of the vehicles and are trained to look for people and things that may be hazardous to their operation; however, due to limited visibility, poor illumination, concentration on the load, or other things, they may not see you. Don't count on the driver or operator of the vehicle to watch out for you. Watch out for yourself.	Example of why operator may not see you: (1) lighting (2) visibility (3) not knowing you are there (4) concentration on other things Watch out for No. 1--ME.	Listen and watch.
	What kinds of things can you do to let the driver know where you are? (1) Let driver know you are in area --wave --whistle (2) Stay in line of vision, driver's side	VISUAL--(1) attention, (2) position, (3) clothing, (4) distance, (5) motion	Answer questions; give suggestions.

	Instructor	Media Material	Student
	(3) Wear reflective clothing in low light areas. (4) Stay as far away from moving vehicles as possible. (5) When directing a moving vehicle, move using a sideway motion to watch your step and the vehicle.	VISUAL--Reference with slides of these suggestions.	
	Know the standard hand, light, and audible signals used on your property. Use of standard signals between you and the operator will assure both of you as to what moves are going to be made.	Some standard signals commonly in use. (Use signals used on your property. Handout would help.)	Students identify meaning of signals.
	What does this sound mean? When you hear this sound, STOP, LOOK, LISTEN.	Back up signal sound. STOP-LOOK-LISTEN.	Students answer questions.
	What will you do when working around moving vehicles?	VISUAL-- (1) Know what _____ are operating in your area. (2) Know the _____ that the vehicles normally use. (3) Stay in _____ whenever possible. (4) Wear _____ clothing when light is poor. (5) Let the _____ know you are around. (6) When you hear a backup signal, _____, _____, and _____.	Students fill in blanks.
	Your company will instruct you in the proper walkways and travelways, traffic patterns, signals used, and other safety procedures used when working around moving vehicles. Know and follow the safety procedures.	Company safety policy and procedures. (Handout if possible, or reference to portion of Federal Safety Manual.)	

	Instructor	Media Material	Student
	Stationary Machinery		
	In the working environment of the plant, you will be exposed to stationary machinery. There are dangers that exist around these machines--exposed gears, belts, pulleys, shafts, crushing and grinding actions, and rollers that can pinch and tear. You also run the risk of being struck by ejected machine parts. If you find a machine that is not properly guarded, report it to your supervisor and do not use it until it is fixed.	VISUAL--show exposed machine parts.	Listen and watch.
	In most cases, guards have been designed to separate you from any moving machine parts. These guards should be checked periodically to insure they are working properly. Never take a guard off an operating machine unless following a prescribed maintenance procedure. Another area where potential hazards exist is in the use of hand tools. Grinders, saws, welders, drills, and many other types of hand tools can cause serious safety problems in any working environment. These machines have the potential for throwing broken parts or scraps from the cutting action of the machines. In order to work around these machines safely, you will be instructed as to the types of personal safety equipment to use.	VISUAL--Show correct machine guarding. VISUAL--Removing guard incorrectly. VISUALS--Protective Equipment. (Display of equipment in use on your property helpful.)	Listen and watch.
	Film.	Film, "Accident Prevention Through Equipment Guarding"	

	Instructor	Media Material	Student
	Generally speaking, loose clothing, long hair, and beards are considered unsafe in a working environment where moving machinery is used. If you wear long hair, make sure it fits within your safety hat (hard hat).	VISUALS--Unsafe practices. Ask what is wrong in slides.	Listen, watch, and discuss.
	<u>Protective Equipment</u> Whether using mobile or stationary. machinery, safety protective equipment is important. Some protective equipment that may be used are: --gloves --hardhats --face and eye shields --shoes --ear plugs --respirators	VISUALS--Protective equipment. Handout on protective equipment.	Listen.
	When working around equipment that can throw off material, it is "mandatory"that you wear face protection. In most areas, it is required that you wear a safety hat.	VISUALS--Face and head protection.	Listen.
	(Review company safety policy.) Be sure: (1) machines are correctly guarded (2) you are wearing correct protective equipment (3) you report any defects in equipment to your foreman.	VISUAL--Review; or write it on blackboard.	Listen.
	Instructor Note--A discussion of the pertinent subjects should be used at the end of this section. A handout will come with this course to help you in a discussion and answer period.	Hand out quick check.	

QUICK CHECK -- STATIONARY EQUIPMENT AND PROTECTIVE EQUIPMENT

1. In your own words what is machine guarding? _____

_____

_____

_____

_____

2. What hazards can be caused by power hand tools? _____

_____

_____

_____

3. List six kinds of protective equipment.

_____

_____

_____

4. From Question 3, take one of your answers and describe when it should be used.

_____

_____

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_____

	Instructor	Media Material	Student
1-Introduction	Slips and Falls A. Falling (same level) B. Falling (lower level)	*Hand out pamphlet, "The Big Fall," Dray Publications*	Listen.
2-Falling Same Level	Slips and falls on the same level often result from poor housekeeping or poor physical conditions on the walking and working surfaces. By good housekeeping, most hazards that cause slips and falls could be eliminated.	VISUALS--Potential hazards that may cause slips and falls.	Listen.
	Pick out the slip and fall hazards from the following 35 mm slides.	VISUALS-- (1) Oil and water spills (2) Dirt and dust (3) Electrical cord in walkway (4) Uneven surface (5) Obstructed walkways (6) Poor illumination (7) Improper shoes (8) Horseplay	Listen. Look and point out. Discussion by instructor and class. Individual can list.
	How could these hazards be eliminated?	Instructor list for board presentation (1) Pick up (2) Clean up (3) No horseplay (4) Report to foreman (5) Awareness of hazard (6) Proper shoes or boots	Discussion. Answers from class.

	Instructor	Media Material	Student
3-Falling Lower Level	Falls to lower levels can potentially cause more serious accidents than falls on the same level. Extra precautions should be made when operating in areas that require you to be off the ground. Accidents of this type usually result from poorly secured, old, cracked, and rusted ladders; unguarded openings in floors; lack of proper guardrails; and any areas that are unguarded above the ground level.	VISUALS--Areas where lower level falls could occur.	Listen.
	When working on equipment off the ground, check over guardrails and safety equipment. Equipment should be in good working order. Make sure lifelines and safety belts are used in areas where they are required. Point out the safety factors in each of these slides.	VISUALS--Areas showing: (1) Steps and handrails (2) Catwalks and guardrails (3) Safety chains on openings	Watch and listen. Discussion.
	When using a step ladder or extension ladder, secure the feet of the ladder on a firm foundation. Use both hands when climbing and always face the ladder. There is no excuse for using ladders and other climbing devices that are not in proper condition. Report any defects to your foreman immediately.	VISUALS--Areas showing: (1) ladder placement (2) climbing a ladder (3) coming down a ladder	Watch and listen. Discussion
	Instructor Note--If teaching this program to a single company, housekeeping rules and regulations should be included into this section.	Company safety procedures.	Questions and discussion.

	Instructor	Media Material	Student
4-Quick Check	What's wrong in these pictures and how would you correct it? If the situation is correctable, correct it.	VISUAL--Slide of: (1) Ladder on muddy surface --firm placement (2) Safety chain --chain being put in place (3) Trash on stairway (4) Oil spill on walkway (5) Broken surface (6) Leaning over without safety line or belt (7) Any other slides that may show unsafe conditions	Class discussion. View and correct. Then, show corrected slides.

	Instructor	Media Material	Student
1-Introduction	Communications *Instructor Note--This module is intended to develop student awareness of the importance of communication systems in his working environment. This insert can be used anywhere in the courses at the discretion of the instructor.* Communications systems have been developed to inform the workforce about what is needed or going on within the operations and to let management know what is happening in your area. Sometimes the communications are one way and at other time we get a chance to talk back (two way).	VISUAL--Communications: (1) One way (2) Two way	Listen
2-One Way Communications	Some examples of one way communications devices are: (1) Bulletin board (2) Signs (3) Barricades (4) Flashing lights (5) Horns (6) Whistles (7) Sirens (8) Bells (9) Labels	VISUAL--Worksheet. Have students list different types of one way communications.	Discuss and add methods. Write down with instructor on worksheet.
	Can you think of any more? What would these communications devices be used for? (1) Bulletin board --pay day --special events --laws and protection	VISUAL--Worksheet	Discuss and fill in worksheet.

	Instructor	Media Material	Student
2-One Way Communications (Continued)	--changes in procedures --last injury in area --special information (2) Signs --exits --walkways --restricted areas --hazardous materials --speed limits --operating instructions (3) Barricades (Cones) --restricted areas --detours --damaged surface What does a barricade usually mean? Keep out. (4) Flashing lights. Danger. Stop, look, and listen. (5) Horns --Lunch --Break time --Vehicle in area --Get out of way --Special signal for emergency (fire, earthquake, flood, etc.) (6) Whistles --Train in area --Quitting time --Starting time --Special signal for emergency blasting (7) Sirens --Ambulance --Police --Fire --Special emergency	Worksheet.	Discuss and fill in worksheet.

	Instructor	Media Material	Student
2-(Continued)	(8) Bells (9) Labels (color coding) --poisons --flammable liquid --harmful fumes, etc. (Use devices used on your property.)		
3-Quick Check for One Way Communications	These are examples of some of the one way communications devices. What do they mean?	VISUAL-- Signs No smoking (know the rules in your plant for smoking) Restricted area Do not enter Hot pipes Speed 15 m.p.h. Barricades (Two or three examples of each)	Identify and tell.
	What will you do if you see a flashing light? Stop, look, and listen.	Flashing lights	Answer.
	Know the communications devices in your areas. They are there to inform you of what is going on and any hazards that may be present. Look for the signs, barricades, and other visual devices and know what the audible signals such as horns, sirens, and whistles mean on your property.	Company safety policy and procedures.	Listen.

	Instructor	Media Material	Student
4-Two Way Communications	Two way communications allow you to talk back. These include: (1) Radio (2) Telephone (3) Paging systems You will be given instructions as to which system is in use at your operation and how and when it should be used.	VISUAL--Views of Devices	Listen.
	In any emergency situation, it is important that you understand: (1) How to report the emergency --be calm (2) Who to report it to (3) What to report --give exact location (4) Describe the emergency situation (be as brief as possible)	VISUAL--Write on board.	Listen.
	In every plant operation, emergency communications systems have been implemented. These systems will be shown to you and you will learn how to use them in case of an emergency. <u>Be sure you know where the emergency communications systems are located in your working area and know how to use them</u>. *Instructor Note--If this section is being taught to one mine, use its communications system.*		
	Handout of two way communications systems.	Hand out. Go over in class. Have class fill out questions 2 and 3 on worksheet.	Read with instructor.

QUICK CHECK -- COMMUNICATIONS

1. Give some examples of <u>one way</u> communications.

1. Bulletin board

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

2. Signs

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

3. Barricades

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

4. Flashing lights

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

5. Horns

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

6. Whistles

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

7. Sirens

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

8. Bells

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

QUICK CHECK -- COMMUNICATIONS (cont.)

9. Labels

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

10. ?

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

2. What are some two way communications devices?

1. _____

2. _____

3. _____

4. _____

3. In any emergency situation you should know:

1. _____

2. _____

3. _____

4. _____

Lifting--

	Instructor	Media Material	Student
1-Introduction	Introduction to lifting.	Before class starts, hand out material on proper lifting and discussion check-list.	Listen.
	Twenty-five million Americans, or 1/8 of the country's total population, suffer painful and incapacitating back problems annually. This, in turn, has an adverse effect on industry through lost man-hours and production.	VISUAL--Introduction to lifting showing statistics. (Use statistics of your plant or area, if available.)	Listen.
	Because back problems are difficult to treat, the answer lies in the prevention of them.	VISUAL--Prevention, key to back problems.	Listen.
2-Anatomy of Spinal Column	The back bone consists of many vertebrae constituting the spinal column. Discs between the vertebrae permit some twisting and bending.	VISUAL--Spinal column showing the discs.	Listen and watch.
	The bottom five vertebrae, known as the sacroiliac, carry the weight of the upper body. This area of the back causes most of the back problems.	VISUAL--Show lower five vertebrae.	
	All the bones are connected by joints which provide us freedom of movement and flexibility. The bones are held in place by ligaments and muscles control the movement.	VISUAL--Show connections on visual.	
	Damage to any of these three elements can bring on excruciating pain and incapacity.	VISUAL--Pain!!	

	Instructor	Media Material	Student
3-Lifting	Some back ailments are brought on by poor posture, most are caused by: (1) improper lifting (2) slipping (3) impact Most of these types of falls affect the lower back. In the most severe circumstances, a disc can slip out of place or become ruptured, often requiring surgery.	VISUAL--Show slides of incorrect lifting, slipping caused by poor housekeeping, falling off or stepping down incorrectly. VISUAL--Lifting-slipping-impact	Listen.
	Most back injuries are caused by improper transfer of materials. The three basic types of transferring material are: (1) lifting (2) pushing (3) pulling	VISUAL--Slides of incorrect lifting, pushing, and pulling. Describe in each slide what is incorrect.	Listen and discuss.
	The limits to which you can perform any of these moves, of course, depends largely on your physical condition. But, regardless of your physical size or condition, there are some points everyone should remember before moving anything. (1) Size up the load. (2) Is it heavy? (3) Is it bulky? (4) Does it have sharp edges that may injure your hands or cause you to drop the load? (5) Will it block your vision? (6) If you need help, get it. It's better to get help than to develop back problems.	VISUAL--Slides of six points that should be remembered.	Listen and discuss.

	Instructor	Media Material	Student
4-Movie and Discussion	Film. Talk about the movie and check quiz. Make sure lifting is down correctly. (Note, the following items will correspond with the check quiz. Go through the check quiz and demonstrate simultaneously.) (1) Foot position (one alongside and one behind) (2) Back (straight) (3) Chin (tucked) (4) Palm (palmer grip) (5) Body weight (centered) (6) Arm position (close to body) Talk about lifting away from your body. Something weighing 50 pounds equals 500 pounds when it is stretched out in front of you. Talk about twisting. Move your feet, not your back. Have one foot turned in the direction of movement.	Film and hand out small check quiz to be answered after film. (located at end of module.) Demonstration.	Film. Have students demonstrate correct lifting procedure using a fairly heavy object. Discussion on heavy lifting and check quiz. Demonstrate correct method of lifting and turning.
5-Prevention of Back Strain	The results from imbalance, muscle strain, and fatigue are just as important factors in back injuries as improper lifting, pulling, and pushing. Be sure your back gets correct rest and posture in your daily activities. (1) Sit up straight. (2) Stand straight.	Slides of correct posture and prevention of back problems.	Listen.

	Instructor	Media Material	Student
5- Prevention (Continued)	(3) Do not stay bent over for long periods of time. (4) If you must stand for long periods of time, place one leg on a chair. This will reduce strain.	Go over six steps in lifting.	
6-Conclusion	Final discussion.		Discussion.

QUICK CHECK -- LIFTING

1. Most back ailments are caused by:

   1. _____

   2. _____

   3. _____

2. The three basis types of transferring materials are:

   1. _____

   2. _____

   3. _____

3. What are the six steps in proper lifting?

   1. _____

   2. _____

   3. _____

   4. _____

   5. _____

   6. _____

	Instructor	Media Material	Student
	Health (Hygiene)		
	In today's working environment, there are many inherent hazards that exist. By using protective equipment, all of these hazards can be eliminated. We have already discussed different types of protective equipment that protect the external portions of your body--hard hats, eye and face shields, proper clothing, gloves, boots.	VISUALS--External Protective Equipment	Listen.
	By using this equipment properly, you will have adequate protection for your extremities.		
	But what about your internal parts? What, if any, protection is needed? All mineral industry operations are required by law to furnish a safe, healthful working environment.		
	A. To accomplish this, each employer monitors the working environment for dust and noise on a regular basis. To assist the companies in their efforts, MSHA inspectors also monitor operations for dust, fumes, and noise in the work areas.	VISUALS--Plant being checked for dust and noise. Show devices used and explain importance of proper measurement.	Listen.
	B. To assure a healthful workplace, the employers have installed various types of engineering devices to remove excessive dust, fumes, and noise from the work area. The types most commonly used for removing dust and fumes are:		

	Instructor	Media Material	Student
	(1) Vacuum systems (2) Ventilation systems --hoods --fans	VISUAL--Vacuum system visuals. VISUAL--Ventilation of clean work area.	Listen.
	C. These systems, in conjunction with good housekeeping procedures, keep most areas free of hazardous dust and fumes.		
	D. In areas where the dust or fumes cannot be controlled to acceptable limits by existing engineering, additional protection is required in the form of personal protective respirators.		
	E. There are several types of respirators that have been approved for dusty atmospheres. The respirator your company uses has been determined by the nature of the dust and atmosphere you will be working in.	VISUAL--Types of respirators (use models, if available)	
	F. These respirators, when used properly, will remove dust particles considered as nuisance dust as well as respriable dust particles that may be considered health hazards.		
	G. If your working station requires the use of a respirator, use it at all times. Respirable dust particles can be so small that you can't see them. Even in areas where the respirators are required look clean, they may not be.		

	Instructor	Media Material	Student
	Protection from dusts and fumes.		
	To combat any contaminant problems, there are two principle types of respiratory devices. These are: (1) Oxygen or air supplying respirators to combat the oxygen deficiency and aerosol problems. (2) Air purifying respirators to combat particle contaminants.	Visuals of oxygen supplying respirators and air purifying respirators.	Listen.
	We will not be concerning ourselves with the air supplying respirators. We will be looking at the types of air purifying respirators.	(Select material related to respirators used on your property.).	
	Each one of you required to wear a respiratory device must be familiar with its: (1) function (2) care (3) limitations The important thing is to know when a respirator is called for and to be sure you have the proper one. You will be instructed at your plant to the type of respirators needed and when to use them.	Write on board: (1) function (2) care (3) limitations	Listen.
	Three basic types of air purifying respirators: (1) mechanical filter (2) chemical absorber (3) chemical-mechanical filter The respirator, to do its job, needs to fit snugly over your nose and mouth so that all the air you breathe comes through the filter. The duration of the	Visual of mechanical filter, chemical absorber, and chemical-mechanical filter.	Listen.

	Instructor	Media Material	Student
	filter is dependent on the type of respirator and the dusts in the air. In all cases, the respirator should be kept in a clean condition and the filter changed at regular intervals. Usually, you can tell when a new filter is needed as it becomes harder to breathe through the respirator.	Demonstration model respirator and filters.	Watch and listen. Handle, if possible.
	(1) Mechanical filter--is a special filter respirator designed to filter only particulate matter such as dust. It is not designed for use in atmospheres that contain toxic gases or vapors that may cause difficulty in breathing. Also, it has limited time of use. Always use a clean filter since they are changeable. Leave the area immediately if you experience difficulty in breathing.	In most operations, the mechanical filter will be commonly used. Several types should be used as a demonstration. (1) When to use (2) How to use (3) How to clean (4) How to change filter	Demonstrate correct procedures pertaining to mechanical-filter usage.
	(2) Chemical absorber--three basic types --universal gas mask --special canister gas mask --special cartridge respirator Each of these is designed to absorb only gases and vapors. Do not use these respirators either in oxygen deficient atmospheres or in areas containing excessive contaminants.	Visuals of chemical absorber filters. Optional--demonstrate correct usage of chemical absorber as is done with the mechanical filter.	Listen. Optional--student will demonstrate correct procedures in using chemical absorber filter.
	(3) Chemical-mechanical filter--is either a gas mask with filter type or a filter with chemical cartridge type. These systems are designed to combat a	Visuals of chemical-mechanical filter. Optional--same as with chemical absorber.	Listen. Optional--same as with chemical absorber.

	Instructor	Media Material	Student
	combination of particulates and gases and vaports. If you are required to wear any of these types of respirators, make sure you are wearing the right one and you understand the correct procedures of operation. Your company can do only so much to make your working environment a safe and healthy one. It is up to you to keep your environment clear from safety and health hazards.		
36	Quick Check (True or False) (1) A respirator should be worn by everybody on the property. (2) Respirators look nice hanging around your neck. (3) Wear your respirator when you can see dust in the area. (4) Put your respirator on loose so you can breathe easier. (5) Clean your respirator semi-annually.	VISUAL--Handout of questions may be used.	Answer and discuss questions.

	Instructor	Media Material	Student
	Noise In areas where controls are not sufficient to control noise to acceptable levels, special protective devices are used.		
	Noise controls are based on the loudness and frequency of the noise. Your exposure to noise is limited to prescribed periods of time at various noise levels. Noise measurements at various work areas are taken to determine levels and exposure times for workers in those areas. The plugs or muffs assigned to you will keep the noise to levels under the limits prescribed by law.	VISUAL--Chart of exposure to noise and acceptable noise levels.	Listen and discuss.
	Many machines operating in your area may have special baffles and enclosures to reduce noise levels for people working in the area. These devices help reduce the noise levels by reducing the amount of sound waves that reach you.	VISUAL-- (1) Mufflers (2) Cabinets (3) Baffles and screens (4) Cabs (5) Enclosures	
	In other cases, enclosures and cabs have been insulated and sealed to reduce noise levels for the operators. It is important that these systems be used and kept in repair. Report any deficiencies in the noise suppression devices in your area to your supervisor immediately.		

	Instructor	Media Material	Student
	In areas where the engineering doesn't reduce the noise levels to permissible levels, noise protection must be worn.	VISUAL--Noise survey showing device to measure noise.	
	Protection from Noise.		
	Loud noises over a prolonged period of time can cause permanent hearing impairments. The effects of loud noises are accumulative and can build up for years before any obvious hearing loss is noticed. Protection from noise is achieved by wearing protective ear muffs or ear plugs. Ear protection removes the high frequency range noises where most damage is done and leaves the lower range noises audible for communication with fellow workers. You will be told at your plant if and when you need to wear any type of ear protection. Make sure you understand when and how to wear these protective devices.	Visuals--Types of ear protection (1) ear muffs (2) ear plugs Quick Check Why is it important to wear protective ear devices in areas of loud noises? (Make class aware of possible effects of not wearing ear protection when required.)	Discussion and answer.

	Instructor	Media Material	Student
	Firefighting Procedures		
	In the event there should be a fire in your plant, you should be aware of the alarm system to use and what procedures to follow.	Introduction	Listen.
	In your walk around training, you will be shown the places where fire alarms are located and what to do if there is a fire. Be sure you are familiar with the systems that are located in your plant and know the correct procedures to follow in the event of a fire.	VISUAL--Know (1) location, (2) procedure.	
	When working with fires and fire extinguishers, it is very important to know the different classes of fires and the correct extinguishing agent to use on each. Using the wrong agent can not only be ineffective but also dangerous.		
	Examples --Water on a magnesium fire can result in an explosion. --Applying water on burning grease or oil can spread the fire. --Applying water on an electrical fire can result in a deadly shock. --Using the wrong agent for extinguishing fuel fires or wood fires can result in flareups or hidden burning.		
	Fires and Fire Extinguishers (Types)		
	There are four basic classes of fires. These classes are determined by the substances involved. Each extinguisher		Listen.

	Instructor	Media Material	Student
	should be labeled according to the class of fire it is designed to be used for. Some fire extinguishers are labeled for more than one type of fire. Most plants today use an "ABC" fire extinguisher. We, in this course, will go through the four types individually. Always check the label before using an extinguisher.	VISUAL--"ABC" fire extinguisher.	
	Class "A" Extinguishers		
	These are labeled with an "A" inside a triangle. Class "A" extinguishers will put out fires that burn with an ember, such as wood, paper, cloth, and rubber. Class "A" fires are put out by removing the heat from the fire. Water can be used on these fires but appropriate dry chemicals will work faster.	VISUAL--"A" extinguisher. VISUAL--Use of "A" extinguisher.	Listen.
	Two types of "A" extinguishers used: (1) Requires that the extinguisher be turned upside down to permit gas forming chemicals to provide pressure to force the liquid out. (2) Requires only the operation of a handle to obtain a stream of extinguishing liquid. When using either of these types, it is important to direct the stream of liquid at the base of the flames (to remove heat from the fire) where the heat source is originated. Think of Class "A" fires as those that leave ashes.	VISUALS--Two types.	

	Instructor	Media Material	Student
	Class "B" Extinguishers		
	These are labeled with a "B" inside a square. Class "B" extinguishers are effective in fighting fires caused by hydrocarbon, fuel oil, benzene, solvents, gasoline, and other petroleum products. Class "B" fires are put out by smothering the fire. When fighting a fire of this type, you should direct the foam over the fire in such a way as to smother and block the path of oxygen to the fire.	VISUAL--Type "B" extinguishers. VISUAL--Use of "B" extinguisher.	Listen.
	As with type "A" extinguishers, type "B" extinguishers are also the type that are turned upside down and the type that are under pressure. Think of class "B" fires as those that involve contents that will boil.	(Instructor may want to use black-board.)	Listen.
	Class "C" Extinguishers		
	These are labeled with a "C" inside a circle. Class "C" extinguishers are designed especially for use on electrical fires. These are fires which occur in or near energized electrical equipment. If possible, the electrical equipment should be shut down. If not possible, only a class "C" extinguisher should be used. When fighting an electrical fire, it is best to smother the fire with the chemical agent. Do not use a conductive agent to put out a class "C" fire unless it has been deenergized. Think of class "C" fires as current fires.	VISUAL--Type "C" extinguishers. VISUAL--Use of "C" extinguisher. (Instructor may want to use black-board.)	Listen. Listen.

	Instructor	Media Material	Student
	Class "D" Extinguishers		
	These are labeled with a "D" inside a star. Class "D" extinguishers are special purpose units used for fighting metal fires such as highly flammable magnesium, sodium, zinc, titanium, aluminum, and potassium. The agent used to stop a class "D" fire is a dry chemical which smothers the fire (removes the air).	VISUAL--Class "D" extinguishers. VISUAL--Use of "D" extinguishers.	Listen.
	Self check should be handed out on the section of contact accidents. This should be gone over by class when complete.		Discussion on self check.
	Conclusion		
	In a working situation, be aware of the types of fire extinguishers that are available and the locations of each.		
	Make sure you understand the firefighting procedures in your plant.		
	Know where the alarm systems, telephone, extinguishers, hoses, and firefighting equipment are located.		
	Above all, in the event of a fire, you must notify the correct people and then evacuate the area.		
	Instructor should have class demonstrate use of extinguishers used on property and go over company fire procedures at this time.	(Handout of procedures.)	

QUICK CHECK -- FIRE EXTINGUISHERS

1. Most plants use a _____ type fire extinguisher.

   A. "A" type
   B. "ABC" type
   C. "D" type
   D. none of the above

2. Class "A" fire extinguishers put out _____.

   A. gas fires
   B. wood fires
   C. magnesium fires
   D. all of the above

3. Class "B" fire extinguishers would most likely be found around a

   _____.

   A. wood mill
   B. transformer
   C. gas station
   D. all of the above

4. In a Class "C" fire, what should be the first thing done?

   _____

   A. call for help
   B. deenergize the system
   C. evacuate the area
   D. use a type "C"fire extinguisher

5. Where would you most likely find a Class "D" fire extinguisher?

   _____

6. Which type of fire would you try to put out by removing the heat?

   _____

   A. B
   B. D
   C. A
   D. C

	Instructor	Media Material	Student
	The problems of slope stability in open pit mines and highwall areas are, for our discussion, similar. In both cases we are concerned with the elimination of the hazard. This may be accomplished by stabilization of the embankment, or, if stabilization is not possible, by determining the areas of potential slides and cave-ins. In this course we will not be concerning ourselves with stabilization techniques, but rather identification and causes of potential slide areas.	Visuals of highwalls and slopes	Listen.
	Definition: a highwall according to the Bureau of Mines is " The unexcavated face of exposed overburden and coal or ore in an opencast mine or the face or bank on the uphill side of a contour strip mine excavation."		Listen.

	Instructor	Media Material	Student
	When working around a highwall make sure you are not undercutting. Undercutting is caused by digging into the bank and leaving an overhang. Be aware--the slope is composed of loose material. Rocks may be loose in a slope and with certain changes in the weather may become more dangerous. After rains and temperature changes, an area may be more likely to slip and cause rock slides.	Visual or draw a simple overhang.	Listen.
	Working around some highwall requires safety harnesses and lifelines. Make sure you are aware of the types of equipment needed when working around highwall areas. When working around highwall, you will be told by your foreman the correct procedures for working in the area. If you feel a situation is unsafe, bring it up with your foreman and, if you are not satisfied with his answer, ask your supervisor. Slide areas should be inspected regularly, but often potential hazards are missed or overlooked.	Visuals of harnesses and lifelines	Listen.
	<u>Be Careful</u>. Instructor should demonstrate use of harnesses and lifelines and insert company policy at this time.	(Handout of company policy.)	

	Instructor	Media Material	Student
	Quick Check (1) What is a highwall? (2) What is undercutting? (3) What factors may cause a slope to become unstable? (4) Why should you report any unsafe condition you see to your supervisor?		Discussion and answer.

	Instructor	Media Material	Student
	Contact Accidents (1) Hazards that create heat and fire (2) Electrical hazards (3) Chemicals and liquid hazards Introduction to Contact Accidents In any working environment, there are many accidents that are caused by "contacting" a hazardous condition--hot and cold pipes, fires, electrical shorts, and dangerous chemicals, just to name a few. In this part of the course, we will be looking at: (1) Hazards that create heat and fire --fires --fire extinguishers (2) Electrical hazards --lock-out procedures	VISUAL--Contact Accidents	Listen and watch.
	Hazards That Create Heat and Fire In your working environment, there are many conditions that can cause fires--flammable liquids, combustible liquids, explosions, electrical shorts, smoking in unauthorized places, lighting, spontaneous combustion, overheated machinery, chemical reactions, and static electricity. These are just a few of the conditions that can and do cause fires.	VISUAL--Media material of different things and conditions that can cause fires.	Listen and watch.
	When handling flammable liquids, combustible liquids, and situations involving chemical reactions, make sure you understand the dangers involved and are aware of the correct procedures and correct protective equipment required.	VISUAL--Dangers	Listen and watch.

	Instructor	Media Material	Student
	Explosions can be prevented by practicing careful work habits and being alert to the surrounding environment. --Know what you are doing. --Know the types of chemicals you are handling. --Know the color coding of containers. --Keep the area well ventilated. --Do not smoke in restricted areas.	VISUALS--Demonstrating the five points.	Listen.
	By being careful and following company rules, you will make your working environment a safer one for yourself and others.	*Instructor Note--Cover company policy with handout or on blackboard.*	
	Instructor Note--Class discussion on the types of fire and chemical hazards found in a plant working environment. Have class name some. Instructor can list them on overhead or blackboard.		Discussion.
	Electrical Hazards In the mining industry, it is impossible to get very far from electrically driven equipment in one form or another. There are motors, vaults, outlets, transformers, instruments, and dozens of other things present in all of our surroundings that could present electrical hazards. With proper training, most hazards commonly associated with electrical accidents can be eliminated.		
	Lockout A major problem involved in electrical accidents stems from the failure to		

	Instructor	Media Material	Student
	lock out equipment prior to performing the work. Never, under any circumstances, attempt to work on any type of machinery until it is properly locked out. --Do not remove guards or wiring. --Do not try to free frozen belts or pulleys. --Do not attempt to tighten couplings. Do none of these things until the machinery is properly locked out.		
	What is a lockout? How is it performed? In each plant, the procedure may vary but the basic essentials are there. We will look at one representive lockout procedure commonly used in the mining industry.	Use flow chart.	Listen.
	When a lockout is required, at least two people are involved--the shift foreman and the shift electrician. These two people have special locks and keys for a lockout. An employee required to work on electrically driven equipment should notify the shift foreman who will then contact the shift electrician and ask that the switch be disengaged. Electricians are absolutely the only persons authorized to do any switching in the control vaults. The electrician will move the circuit breaker to the "OFF" position and, if necessary, pull the fuses. He will visually inspect the breaker to make certain that it is open before locking and tagging the cubicle	Notify Shift Foreman. ↓ Shift Foreman will notify Shift Electrician. ↓ Turn circuit breaker off. ↓ Tag with reason for lockout and person doing the work. ↓	

	Instructor	Media Material	Student
	door. Tags placed on the cubicle door will state the reasons for the lockout and the person for whom the lockout was accomplished. Before proceeding with work on the equipment, the start button will be tried by the person who is to perform the maintenance. This serves as a precaution to make certain that the power is actually off. When the work is completed, all tags and locks will be removed by the person whose name appears on the tags and the shift foreman of his alternate will be notified. The tags should then be torn up and disposed. Be sure you are aware of the correct lock-out procedure used at your plant. This procedure will be taught to you at the plant you will work at.	The person doing the work will test the switch. ↓ When work is completed, tags and locks will be removed by persons whose name is on the tags. ↓ Shift foreman will be notified.	
	Instructor Note--Use this or other flow chart of lockout procedure. When finished describing, film, "Electrical Lockout Procedures," could be used.	VISUAL--Show film.	
	Other problems come from carelessness or poor housekeeping. Extension cords and trailing cables should never be hung over nails or other metal objects having sharp edges. They should be protected at all times. In particular, they should be placed where they can not be run over by equipment.		
	Before you use cords, connections, and guards, you should inspect them to make sure they are in proper working order. If any hazardous conditions exist, bring	VISUAL--Compare correct electrical conditions with incorrect conditions. Correct electrical connections visual.	

	Instructor	Media Material	Student
	them to your foreman's attention immediately. When working around vaults and transformer areas, be careful. These areas can be highly dangerous. Enter them only when necessary and, then, only with the knowledge of your supervisor and the accompainment of an electrician. When carrying metal objects such as pipes, rods, or tool boxes, avoid outlets and other electrical components. Contact with these could result in an accident. Any time you are working in the rain or with water, there is the inherent danger of electrical shock. Electrical motors and other electrical equipment must never be cleaned with water or steam regardless of whether or not they are operating at the time. A particular problem in electrical safety is the use of cranes and other hoists around high voltage electrical wiring. Although you may seldom or never be required to operate such equipment, it is likely that you will be in areas where such equipment is being used. Never set a motor overload or place your hands inside a motor starter. You could come into contact with as much as 480 volts alternating current which could prove fatal. Never wear jewelry around electrical components. It is actually a good idea to not wear jewelry at all while working.		

	Instructor	Media Material	Student
	Should an accident occur involving a person hung up on high voltage current, there are only two methods of rescuing the person. (1) Cut the power. (2) Insulate yourself from the victim using rope, rubber, blanket, or length of dry board. Anything that is nonconductive will work. Make sure it is nonconductive before using it. Whenever rescue from electrical shock is made, medical treatment is required. Seek help immediately. If the victim is not unconscious, make him lie down and treat him for physical shock. If the victim is not breathing, perform mouth-to-mouth resuscitation. If no pulse if present, cardiopulmonary resuscitation is required. Grounding Most of us tend to regard static electricity as somewhat mysterious and to highly underrate its potential fire and explosion hazard. It is mysterious in that it is weightless, colorless, and incapable of description except in the most technical terms. Underrating static electricity's potential fire and explosion hazard must be considered as a serious threat to the safety and welfare of all employees. The most effective and widely used procedure for the control of static		

	Instructor	Media Material	Student
	electricity is called grounding. In simple terms, this means that as soon as static electricity is formed (generated), it is harmlessly conducted away to the ground or earth. Thus, grounding prevents the accumulation of static charge and thereby eliminates the possibility of static sparks from becomming a source of ignition.	Quick Check. Discussion--what is grounding? What is lockout procedure?	

	Instructor	Media Material	Student
	Instructor note: this schedule is designed to be used with the communication section, if explosives are being used on the property. The materials are designed to familiarize the miner with warning devices associated with blasting operations. These materials can be modified to accommodate a particular operations blasting policy.		Listen.
	In general, blasting usually occurs during the shift changes or lunch break or at designated times. Procedures used as safety precautions to insure that miners are located in an area removed from the blasting area include:		
	(A) Blasting Areas Blasting areas in surface mining operations are blocked off by various types of warning devices. (1) Barricades (2) Cones (3) Flashing Lights (4) Warning Signs (5) Flagmen (6) Combination of the above In addition, sirens and other audible warning devices are sometimes used to warn of an upcoming blast. Be aware of what these audible devices are used for and what they each represent.	Visuals of warning devices.	Discussion.
	Company should insert specific policy on blasting here.	Handout-company blasting policy.	

	Instructor	Media Material	Student
	(B) Storage of Explosives (Magazines) Working around and in explosive storage areas requires special care and handling for a safe work place. All safety requirements must be followed completely. It is important that <u>every</u> safety step is observed. Here is a list of safety steps to observe: (1) No smoking (2) No horseplay (3) Follow all safety instructions (4) Handle explosives using prescribed procedures (5) Keep area clean (6) Authorized personnel only are allowed in magazine and storage areas In your plant operation, you will be told the specific safety procedures and warning devices associated with working around and handling explosives. Know safety procedures and follow them. (C) Transportation of explosives All equipment used to move explosives from a magazine to a blasting will be marked and maintained in a manner prescribed by law and correct safety procedures: (1) Stay clear of explosive transporters at all times.		Listen

Spray Lines

The spray lines that were on the top of the heap were used (2 inch black plastic) and were fitted with six directional sprinklers and three direct spray sprinklers.

Preg-Spray Pond

Filled with 15,000 gallons or 62.5 tons of water from the West Side mine.

Laboratory

Eocene still runs our solution samples. However, I can only have solutions analyzed at certain times during the day-usually in the afternoon. To properly monitor our plant and to design our leaching systems for various ore types, we desperately need our own atomic absorption unit.

Trailer

The trailer will be used for the laboratory and the plant.

Tanks

Most tanks are available, but some could be purchased at a latter date from George Jewitt.

Chemicals

Purchased to date are the following:

A. HNO_3 and HCl (Nitric and Hydrochloric acids) - for lab

B. Zinc dust; 300 #

C. Sodium thiosulfate

D. Diatamaceous Earth

To be delivered soon:

A. Lime from Paul Spur near Douglas, Arizona

B. Sodium sulfide (Na_2S); held-up by the Teamsters Strike

C. Sulphuric acid from Apache Powder near St. David.

"BREAK-THROUGH CHEMICAL COSTS"

A. Lime; Paul Spur Lime, Douglas, Arizona

"Stack Dust" =$14/ton

Lime/ton ore	$Lime/ton ore
5	$ 0.035
10	.070
15	.105
20	.140
25	.175
30	.210

B. Sulfuric Acid; Apache Powder, St. David, Arizona

$6/100% ton

Tank Car = 22 tons
Acid is 70%

Cost:

15(tons 100%)($6/ton)	=	$ 90
Transportation	=	50
		$140

Cost per pound(H_2SO_4) = $0.0032

Cost per gallon(H_2SO_4) = .0265

TOMBSTONE ACTIVITIES

(Operations)
****

CATEGORY	SPRAY SIDE SLOPES	CRUSH HEAP	OPEN-PIT MINING
Power	220-Single Phase	480-3 Phase	480-3 Phase
Water Line	2700 feet	2700 feet	2700 feet
Spray Lines	540'-2 inch	500'-2 inch	1000'-2 inch
Preg Pond	Liner & Cut	Liner & Cut	Lower Pond
Laboratory	Escapule/Eocene	Own AA/Crush.	Own AA/Crush/Pulv.
Building	Trailer	Trailer	Metal Bldg.
Plant	200 GPM	300 GPM	400 GPM
Tanks	1350 Gallon	1350 Gallon	2-2,000 Gallon
Chemicals	$ 2,211(Initial)	$ 6,000(Initial)	$ 10,000(Initial)
Pumps	220-Single Phase	480-3 Phase	480-3 Phase
Fencing	Around Plant	Around Gun Co.	Around Open-Pit
Pad	--	Small	Larger
Crushing Equipment	--	Jaw & Cone	Larger
"IPS" Feeders	--	5-ton	10-ton
"IPS" Storage	--	20-ton	40-ton
Mining Equipment	--	Loader	Air-trak/compressor Loader/trucks/dozer

ORE RESERVES

TOMBSTONE

Open Pit Samples
Contention Dike

Summary of Contention Dike Open-Pit Samples:

Sample Identification	T.Oz./ton ore		Gross Value/ton ore
	Gold	Silver	($250/$7.50)
Channel Coarse	.126	.39	$ 34.43
A-Fines/coarse/mixed	.130	1.32	42.40
B-Fines/coarse/mixed	.135	2.88	55.35
C-Coarse	.105	.48	29.85
D-Fines/Coarse	.158	1.94	54.05
Ave.	.158	1.94	$ 36.00 .....

TOMBSTONE HEAP

Following are recent samples taken from the heap, grouped by screen size and mineral:

Ore Type	Troy Oz./Ton		Value*		Total Value
	Au	Ag	Au	Ag	
Clay	.041	.26	$10.25	$1.95	$12.20
Fines	.086	.29	21.38	2.18	23.56
Large	.038	.53	9.38	3.94	13.32
Manganese	.155	1.44	38.75	10.80	49.55

The above were weighted by their respective weight percent age (15%,25%,40% & 20%) and the average value ($250 Au & $7.50 Ag*) is $22.95. Assuming a 65% recovery, the resulting ore value would be $15.00. The operating costs will be under $5.00 per ton ore, yielding a net operating profit before taxes of $10.00 per ton ore.

SOUTHEAST CLAY

.021 Au/.12 Ag

SOUTHWEST CLAY

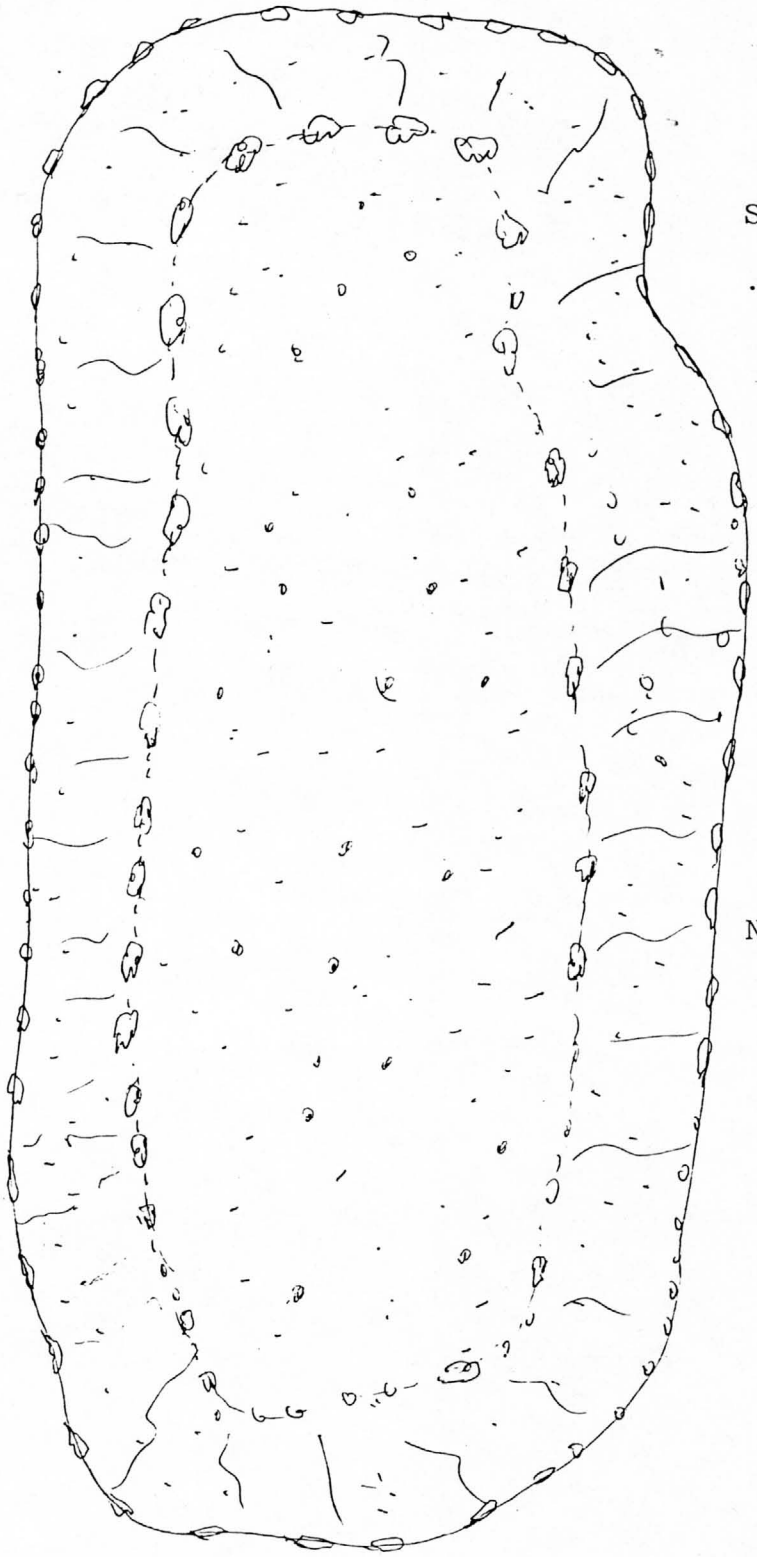
.060 Au/.36 Ag

SOUTH FINES

.120 Au/.42 Ag

SOUTH LARGE

.042 Au/
.57 Ag



SOUTH MANGANESE

.150 Au/1.89 Ag

TOMBSTONE "HEAP"
****
Assays of ore types
and sizes.....

NORTH MANGANESE

East .177 Au/1.98 Ag

West .138 Au/.45 Ag

NORTH CLAY

.042 Au/.30 Ag

NORTH FINES

.051 Au/.15 Ag

NORTH LARGE

.033 Au/.48 Ag

TOMBSTONE

Sampling Summary
March 12, 1979

Location	Ore Type	Troy Oz./ton ore		Gross Value
		Gold	Silver	($250/$7.5)
Heap	Coarse	.038	.53	$ 13.48
"	Clay	.041	.26	12.20
"	Fines	.086	.29	23.56
"	Manganese	.155	1.44	49.55
North Ramp	Contention	.138	1.31	44.33
Emerald Dump	Fines/coarse	.127	2.72	52.15
Contention	Tailings	.050	.63	17.23
Sh-t	Carbonaceous	.234	1.56	70.20
Contention Dike-Cave Open-Pit Area	Altered Dike/ Limestone- No Manganese	.158	1.94	36.00

TOMBSTONE

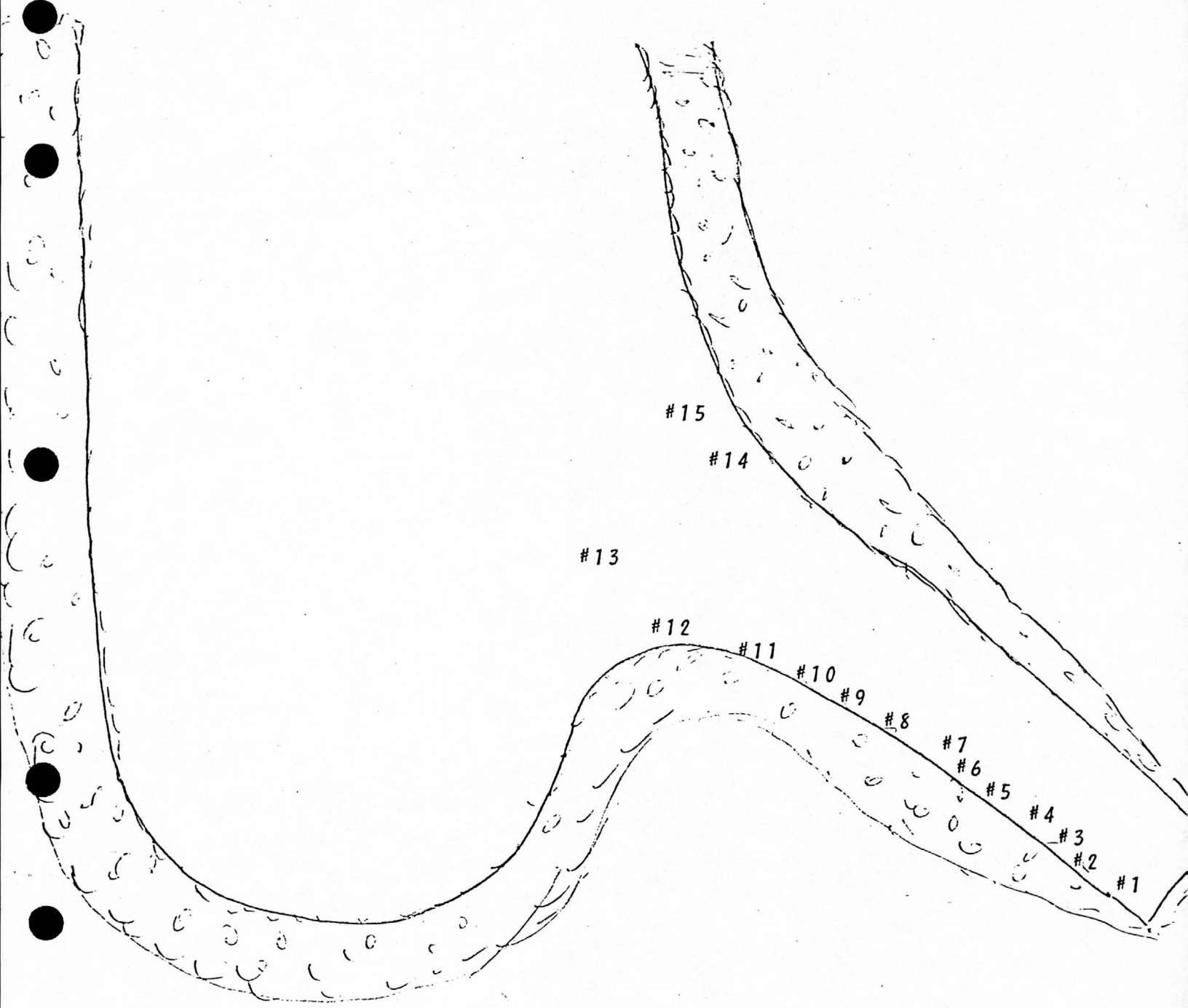
North Ramp Sampling:
(Tom Schloss et. al.)

(C. Escapule Lab Results);

Sample Number	Troy Oz./ton soln.		Troy Oz./ton ore	
	Gold	Silver	Gold	Silver
NR- 1	.043	.31	.129	.93
NR- 2	.040	.38	.120	1.14
NR- 3	.063	1.80	.189	5.40
NR- 4	.039	.24	.117	.72
NR- 5	.043	.41	.129	1.23
NR- 6	.104	.58	.312	1.74
NR- 7	.037	.29	.111	.87
NR- 9	.039	.41	.117	1.23
NR-10	.034	.20	.102	.60
NR-11	.034	.29	.102	.87
NR-12	.040	.29	.120	.87
NR-13	.052	.46	.156	1.38
NR-14	.039	.20	.117	.60
NR-15	.037	.25	.111	.75
		Ave.	.138	1.31

TOMBSTONE

North Ramp Sample Map:



NORTH !

TOMBSTONE

Open Pit Samples
Contention Dike

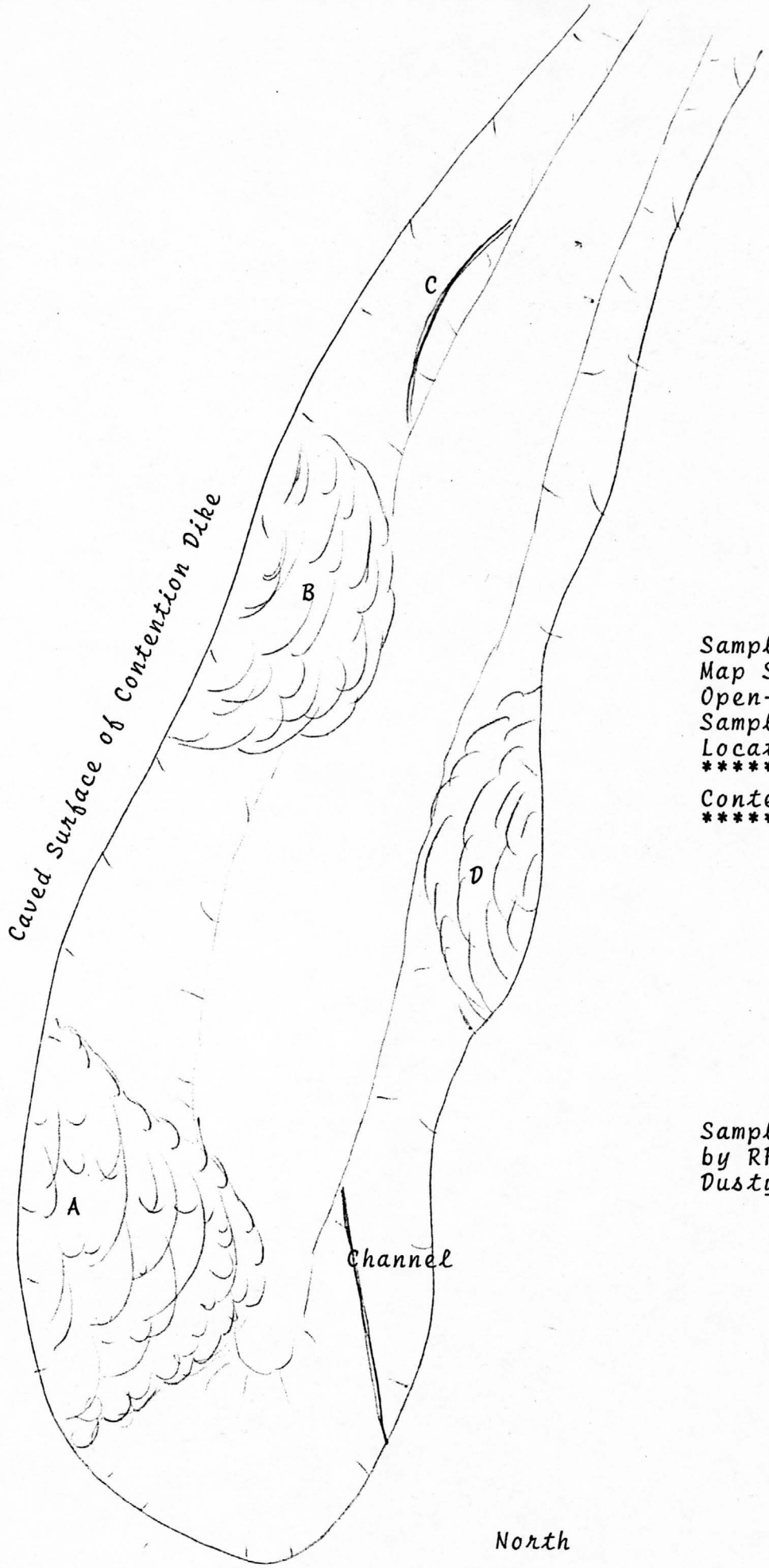
Summary of Contention Dike Open-Pit Samples:

Sample Identification	T.Oz./ton ore		Gross Value/ton ore
	Gold	Silver	($250/$7.50)
Channel Coarse	.126	.39	$ 34.43
A-Fines/coarse/mixed	.130	1.32	42.40
B-Fines/coarse/mixed	.135	2.88	55.35
C-Coarse	.105	.48	29.85
D-Fines/Coarse	.158	1.94	54.05
Ave.	.158	1.94	$ 36.00 .....

TOMBSTONE

Open Pit Samples
Contention Dike

Sample Identification	T.Oz./ton soln.		T.Oz./ton ore		Gross Value Ton Ore ($250/$7.5)
	Gold	Silver	Gold	Silver	
Channel Sample along Contention Dike	.042	.13	.126	.39	$ 34.43
A- Fines	.060	.70	.180	2.10	60.75
A- Mixed(mine run)	.035	.25	.105	.75	31.88
A- Coarse	.035	.37	.105	1.11	34.58
B- Fines	.055	2.03	.165	6.09	86.93
B- Mixed(mine run)	.040	.35	.120	1.05	37.88
B- Coarse	.040	.50	.120	1.50	41.25
C- Coarse(Channel)	.035	.16	.105	.48	29.85
D- Fines	.050	.96	.150	2.88	59.10
D- Coarse	.055	.33	.165	.99	48.68



Sample Location
Map Showing
Open-Pit
Sample
Locations
****

Contention Dike
****

Sampled March 11, 1979
by RF Hewlett and
Dusty Escapule.....

TOMBSTONE

Special Samples:
(Tom Schloss et. al.)

(C. Escapule Lab Results);

Sample Number	Troy Oz./ton soln.		Troy Oz./ton ore	
	Gold	Silver	Gold	Silver
Emerald Dump;				
Fines	.037	2.14	.111	6.42
Coarse	.060	.38	.180	1.14
High Ag	.026	.70	.078	2.10
Hot H	.046	.40	.138	1.20
			.127	2.72
Contention Tailings;				
East	.010	.21	.030	.63
Middle	.017	.28	.051	.84
West	.023	.14	.069	.42
			.050	.63
Sh-t	.078	.52	.234	1.56

TOMBSTONE

Special Samples

CYANIDE vs. ACID LEACH:

To estimate the effectiveness of cyanide as a leaching solvent without pre-treatment, samples taken from the same location were leached with cyanide and aqua regia to determine the relative recoveries. It is known that aqua regia will dissolve all of the gold and some of the silver, making aqua regia a good estimator of total value(heads). For gold, aqua regia is more precise than fire assays, and with the use of an atomic absorption machine, is much faster. Following are the results:

	CYANIDE		AQUA REGIA		PerCent CYANIDE RECOVERY
	T.Oz./ton soln.		T.Oz./ton soln.		
Ore Type	Gold	Silver	Gold	Silver	Gold
Sh-t	.020	.27	.070	.42	29 %
Emerald Fines	.005	.24	.045	.21	11 %
Contention Tails	.020	.21	.047	.08	43 %
North Ramp-6-	.025	2.85	.082	.52	30 %

The above cyanide-aqua regia comparison confirms Ralph VanArsdale's statement concerning the recovery of only 10% of the values from the manganifeous ore left in the Emerald dump and what was hauled to the heap and leached.

'71 MINERALS CYANIDE LEACH TESTS

Notice that the projected recoveries were all low(under 50%) for a cyanide leach. Realize further that cyanide was used to determine the dump grade which does not reflect the true total grade(heads).

December 23, 1974

Memo to: R. J. Hewlett

From: R. M. Darrah

Subject: Tombstone Metallurgical Test Results

The results for the second series of cyanide leaching test to evaluate heap leaching are as follows:

Test	Dump	Gold Leached, oz/ton 1 day	Gold Leached, oz/ton 2 days	Silver Leached, oz/ton 1 day	Silver Leached, oz/ton 2 days
10	Tranquility	.016	.023	.35	.45
11	Empire	.015	.022	.23	.32
12	Toughnut	.008	.010	.26	.32
13	Contention 1	.024	.030	.52	.70
14	Little Joe	.006	.008	.34	.53
15	West Side	.013	.018	.44	.60
16	Grand Central	.007	.010	.59	.76
17	Lucky Cuss	.018	.024	.51	.73
18	Emerald	.004	.005	.44	.57
19	Contention	.020	.033	.83	1.18
	Average	.013	.018	.46	.62

Using $4.50 per troy oz. for silver, and $185 per troy oz. for gold, the total leached values in $/ton for 2 days leaching are as follows:

Tranquility.....6.30	West Side.....6.11
Empire.....5.43	Grand Central.. 5.31
Toughnut..... 3.20	Lucky Cuss..... 7.75
Contention 1 ... 8.80	Emerald..... 3.53
Little Joe..... 3.92	Contention 2 ..11.35

The total silver recovery for 2 days is $2.77 per ton and gold recovery is $3.40 per ton, for a total gold and silver average of $6.17/ton.

Cyanide consumption in 2 days has been about one pound per ton with the exception of Contention 1 and Lucky Cuss, which have used about two pounds per ton. Lime consumption for two days is about 1.5 pounds per ton.

The above results are extremely encouraging in regards to the economics and viability of heap leaching.

A recommendation to proceed with the initial 50,000 ton production test will be made when tests 10 - 19 are completed. This will be around Jan. 3, 1975.

Robert M. Darrah
Consulting metallurgist

cc: Jim Kennedy
File (2)

Projected Gold and Silver
Production From Heap
Leaching the Tombstone Dumps

December 30, 1974

		U. S. Dollars/short ton		
Dump	Estimated Tons	Recovery 1/	Net Profit 2/	$Profit 3/
Contention 1	100,000	7.00	4.00	400,000
Lucky Cuss	55,000	5.90	2.90	159,500
Contention 2	20,000	10.58	7.58	151,600
Tranquility	50,000	5.39	2.39	119,500
Grand Central	50,000	4.61	1.61	80,500
Empire	40,000	4.32	1.32	52,800
West-Side	10,000	5.41	2.41	24,100
Totals/Aver.	325,000			988,000

1/ Based on $4.50/troy oz. silver, $185/troy oz. gold
2/ For $3.00/ton net operating cost
3/ Tonnage x net profit/short ton

Mining and Leaching
Sequence, Tombstone
Waste Dumps

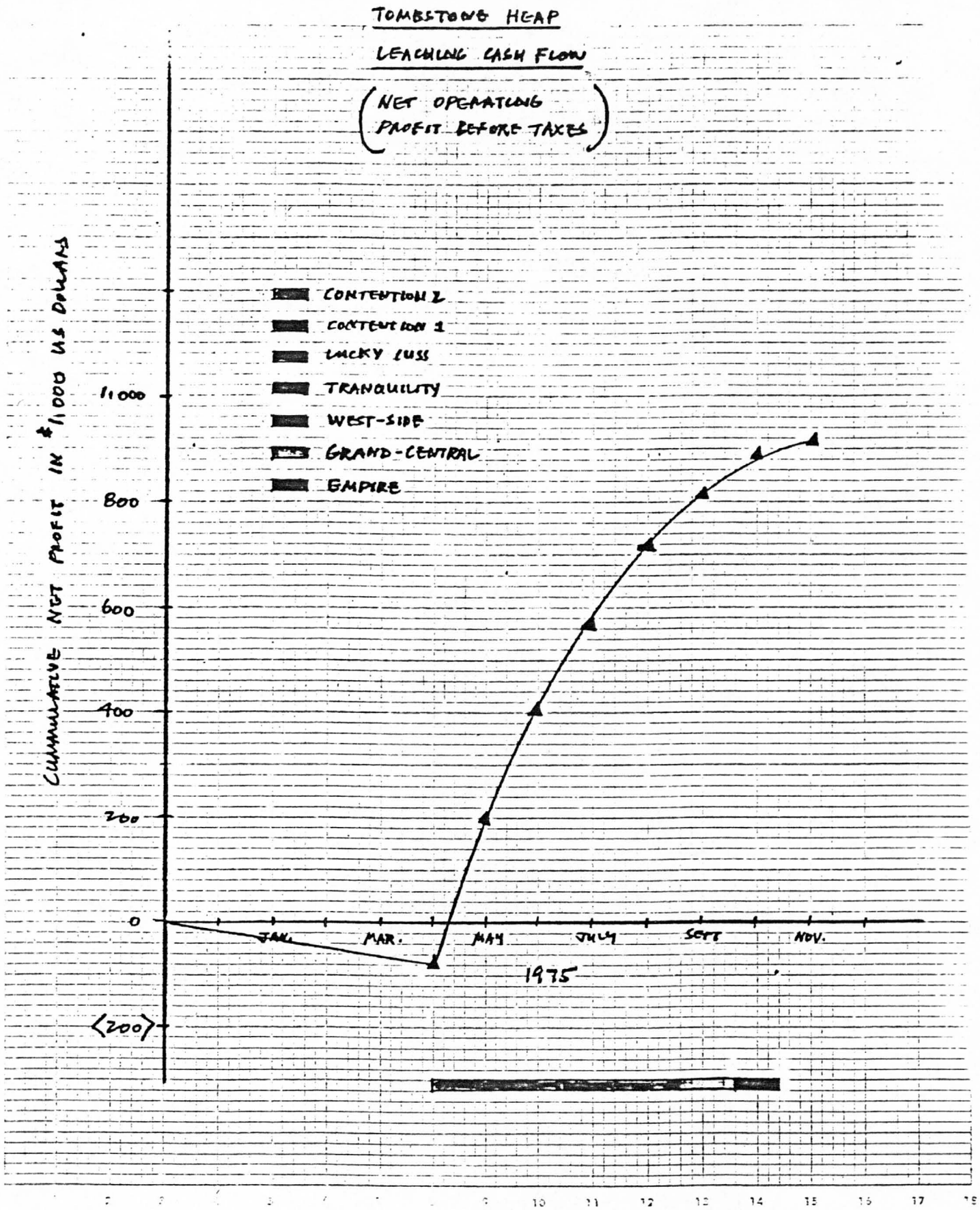
Leach Period	Tonnage	Dump	Production, $	Net Profit $
April 1975	20,000	Contention 2	211,600	151,600
April 1975	30,000	Contention 1	210,000	120,000
May 1975	50,000	Contention 1	350,000	200,000
June 1975	20,000	Contention 1	140,000	80,000
June 1975	30,000	Lucky Cuss	177,000	87,000
July 1975	25,000	Lucky Cuss	147,500	72,500
July 1975	30,000	Tranquility	161,700	71,700
Aug. 1975	20,000	Tranquility	107,800	47,800
Aug. 1975	10,000	West Side	54,100	24,100
Aug. 1975	20,000	Grand Central	92,200	32,200
Sept. 1975	30,000	Grand Central	138,300	48,300
Sept. 1975	20,000	Empire	86,400	26,400
Oct. 1975	30,000	Empire	86,400	26,400
Totals	325,000		1,963,000	987,800

Month	Production $	Net Profit $	Cum. Net Profit $
April 1975	421,600	271,600	271,600
May 1975	350,000	200,000	471,600
June 1975	317,000	167,000	638,600
July 1975	309,200	144,200	782,800
Aug. 1975	254,100	104,100	886,900
Sept. 1975	224,700	74,700	961,600
Oct. 1975	86,400	26,400	988,000

Summary of
Cyanide Leach Tests

Test	Dump	Metal leached, Mg. Silver	Metal leached, Mg. Gold	Metal leached tr oz/ton ore Silver	Metal leached tr oz/ton ore Gold
10	Tranquility	1449	78	0.37	0.0200
11	Empire	1061	65	0.27	0.0167
12	Toughnut	962	27	0.25	0.0070
13	Contention 1	2155	95	0.55	0.0244
14	Little Joe	1711	30	0.44	0.0077
15	West Side	2217	60	0.57	0.0154
16	Grand Central	2345	40	0.60	0.0103
17	Lucky Cuss	2192	71	0.56	0.0182
18	Emerald	1831	18	0.47	0.0046
19	Contention 2	4419	115	1.14	0.0295
	Average			0.52	0.0154

Sample size, pounds.....	250
Leaching time, days.....	2.0
Washing time, days.....	5.0
Average cyanide consumption, lbs/ton...	1.0
Average lime consumption, lbs/ton.....	1.5
Water usage, tons water/tons ore.....	0.6
Application rate, tons water/day/ton ore	0.1
Extrapolated leach time in days for production head, 50,000 tons/month mining rate, 200 gpm sprayrate.....	22


TOMBSTONE HEAP
LEACHING CASH FLOW
(NET OPERATING PROFIT BEFORE TAXES)
CUMULATIVE NET PROFIT IN $1,000 US DOLLARS
CONTENTION 2
CONTENTION 1
LUCKY LUSS
TRANQUILITY
WEST-SIDE
GRAND-CENTRAL
EMPIRE
1,000
800
600
400
200
0
<200>
JAN.
MAR.
MAY
JULY
SEPT
NOV.
1975

Barrel Tests 1-8 - Calc. recovery in 3 days

Test #	Pump	(1) Channel oz/ton Ag	(1) Channel oz/ton Au	(2) Calc. recovery oz/ton Ag	(2) Calc. recovery oz/ton Au	(3) Calc. % recovered Ag	(3) Calc. % recovered Au	(4) Calc. days for 100% R Ag	(4) Calc. days for 100% R Au
1	Tranquility	1.6	.05	.227	.0062	14.3	12.7	273	428
2	Empire	1.4	.04	.129	.0062	9.1	15.9	184	328
3	Tenderfoot	2.8	.03	.124	.0031	4.4	11.5	270	22
4	Contention	1.5	.04	.399	.0134	27.5	31.9	33	13
5	Little Joe	2.2	.05	.184	.0020	8.2	3.9	45	+∞
6	West-side	1.6	.02	.332	.0052	20.5	27.4	64	15
7	Grand Central	1.4	.03	.770	.0041	53.5	13.7	6	-∞
8	Lucky Cuss	3.4	.04	.504	.0102	15	26.2	61	35

(1) Calc. grade using RJH % Recovery & Calc. oz/ton recovered
i.e. grade Ag = oz/ton Ag recovered ÷ % Recovery Ag
" Au " Au " ÷ % " Au

(2) From test data, but may be low due to Ag & Au ppt' onto carbon, zinc dust, pipe & nails.

(3) Calc. by RJH 12/16

(4) Calc. by RJH 12/16 using first order equation

BECHTEL

TOMBSTONE HEAP LEACH TESTS 12/21/74 AMJ

SAMPLE WEIGHT: 250 LBS.
1 TROY OZ/SHORT TON = 3892 MG/250 LBS.

TEST	DUMP	NaCN used #/TON	MG. LEACHED (17 HRS) SILVER	MG. LEACHED (17 HRS) GOLD	OZ/TON ORE SILVER	OZ/TON ORE GOLD	$/TON ORE 1/ SILVER	$/TON ORE 1/ GOLD
10	TRANQUILITY	0.07	1350.1	61.8	.347	.0159	1.56	2.94
11	EMPIRE	0.34	895.0	58.8	.230	.0151	1.04	2.79
12	TOUGHNUT	0.70	992.5	30.2	.255	.0078	1.15	1.44
13	CONTENTION 1	0.68	2039.3	92.2	.524	.0237	2.35	4.38
14	LITTLE JOE	0.38	1509.1	24.1	.388	.0062	1.74	1.15
15	WEST-SIDE	0.46	1726.0	51.2	.443	.0132	2.00	2.44
16	GRAND CENTRAL	0.08	2289.2	28.0	.588	.0072	2.65	1.33
17	LUCKY CUSS	0.57	1976.1	68.6	.508	.0176	2.28	3.26
18	EMERALD	0.80	1694.4	14.3	.435	.0037	1.96	.68
19	CONTENTION 2	0.32	3218.7	76.0	.827	.0195	3.72	3.61
	AVERAGE	0.44	—	—	.455	.0130	2.05	2.40

1/ BASED ON $4.50/TROY OZ. AG & $185/TR. OZ. AU

HEFLIN

HEFLIN STEEL SUPPLY CO.

HEFLIN - HARRINGTON

INDUSTRIAL PLASTICS INC.

STEEL
252-8941

1111 WEST MARICOPA FRWY.
P. O. BOX 1249
PHOENIX, ARIZONA 85001

PLASTICS
252-7616

#	Doré	Au	Ag
1 BARREL #20 1-9-75	17.22	.39	17.33
2 21	8.1	.19	7.91
3 22	17.50	.18	17.32
4 23	37.32	.05	37.27
5 24	5.75	.19	5.56
6 25	41.8	.02	41.78
7 26	23.08	1.1	21.98
8 27	4.83	.97	3.86
9 28	23.31	.36	22.95
10 29	22.34	.83	21.51
BARREL 24 1-8-24			
11 24	6.12		
GOLD			
12 25	49.12	.020	49.10
13 26	28.03		
14 27	6.24		
15 28	27.97		
16 29	28.15		

1-9-75

Head Assay

Dump	Silver oz/ton G.S.	Silver oz/ton B.T.	Gold oz/ton C.S.	Gold oz/ton B.T.
Tranquility	1.6	1.2	.05	.03
Empire	1.4	2.4	.04	.04
Tomahawk	2.8	1.1	.03	.02
Contentment 1	1.5	1.1	.04	.03
Little Joe	2.2	1.4	.05	.02
West-side	1.6	3.7	.02	.04
Grand Central	1.4	1.3	.03	.04
Lucky Cuss	3.4	3.1	.04	.05
~~Contentment 2~~	~~-~~	~~1.6~~		~~.03~~
Aver.	2.0	1.9	.044	.034

C.S. Channel sample

BT Bunsel test, Calc. head from Sol'n + Sediment.

tests 60-19

CERTIFICATE OF ANALYSIS

Your Sample (S) Were Assayed With The Following Results

Description	Gold Ounces Per. Ton	Silver Ounces Per. Ton	% Lead	% Copper	% Zinc								
Test #30	.078	2.143		Silver Thread									
" #31	.002	.485		Contact									
" #32	.017	.761		Prompter									
" #33	.034	5.105		Hershel									
" #34	0.111	16.881		Bob Ingersoll						#35 - Tribute			
" #37	.013	7.659		Visina						36 - Sulphuret			
" #38	.015	4.706		Defense									

15 JAN 75
DATE

CHARGES

CHEMIST

Doré	AU	AG
20: 17.63	.40	17.23
21: 11.13	.25	10.78
22: 23.42	.15	23.27
23: 46.02	.06	45.96
24: 6.24	.19	6.05
25: 45.36	.02	45.34
26: 28.06	1.28	26.78
27: 5.81	1.13	4.68
28: 28.12	.43	27.69
29: 26.12	.90	25.22

1-8-75

12/18/74
[illegible]

TOMBSTONE BARREL
LEACH TEST 1-8

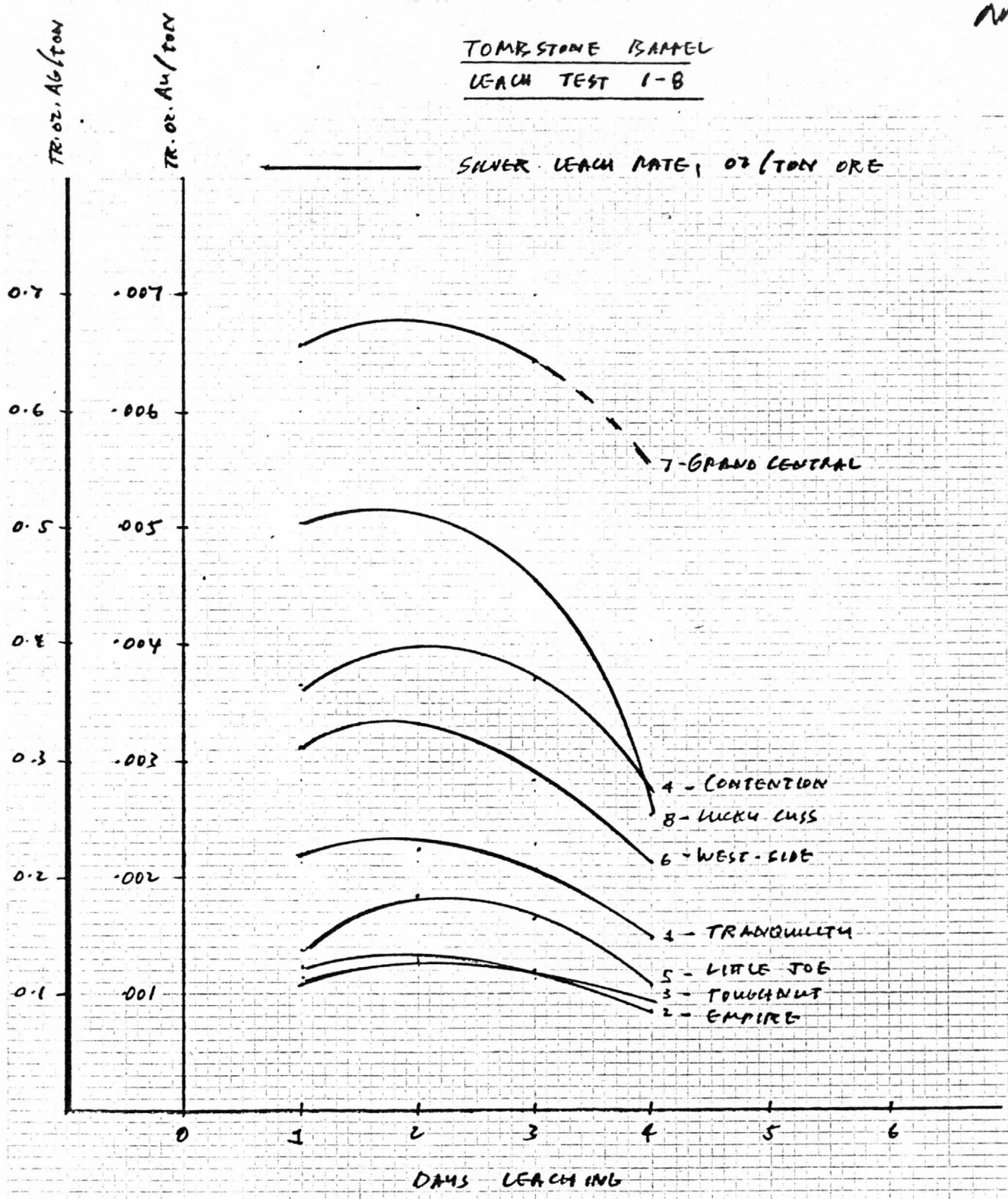


FIG. 5

TOMBSTONE BARREL TESTS 10-19

BASED ON $4.50/oz. AG, $185/oz. AU

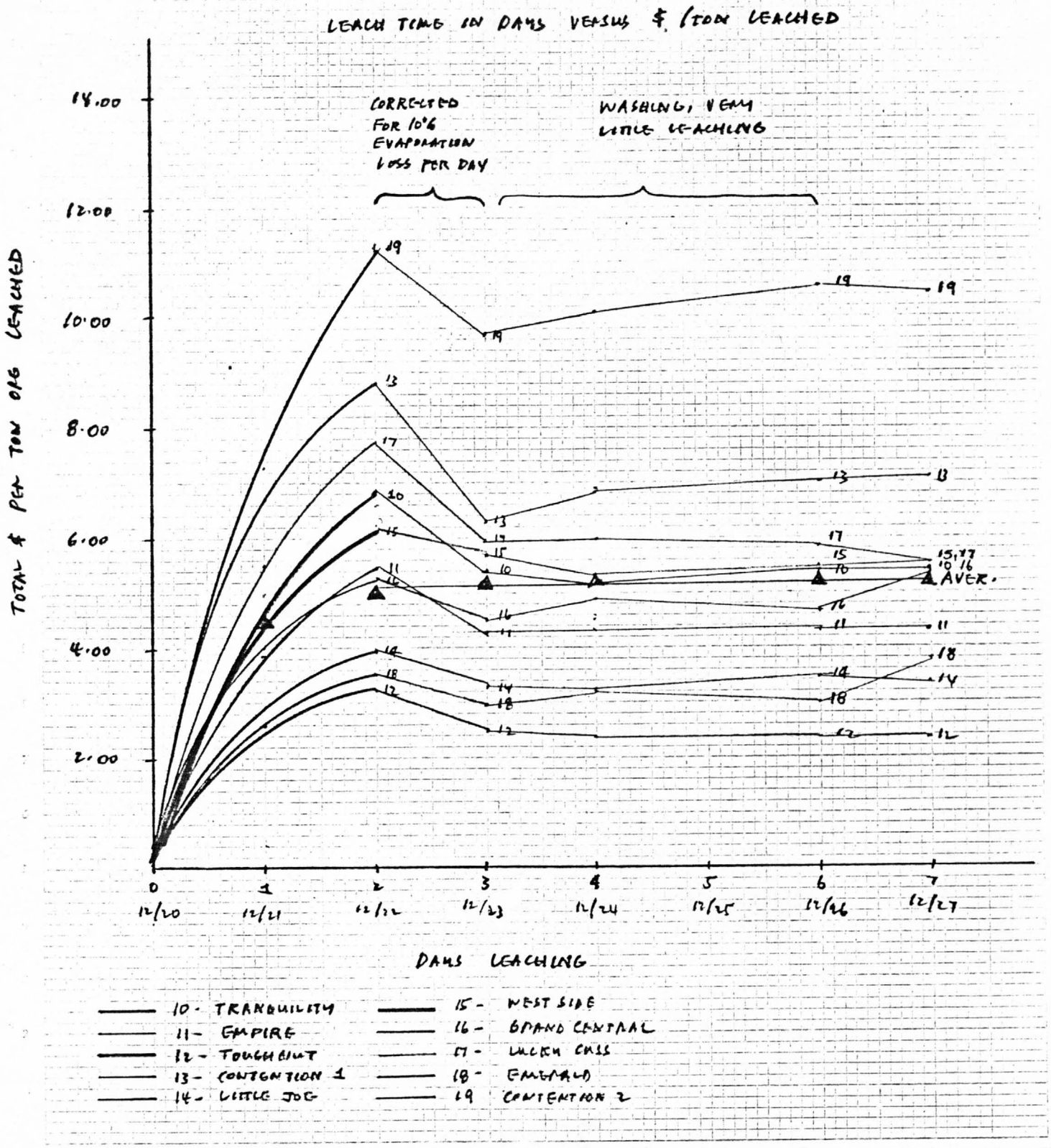
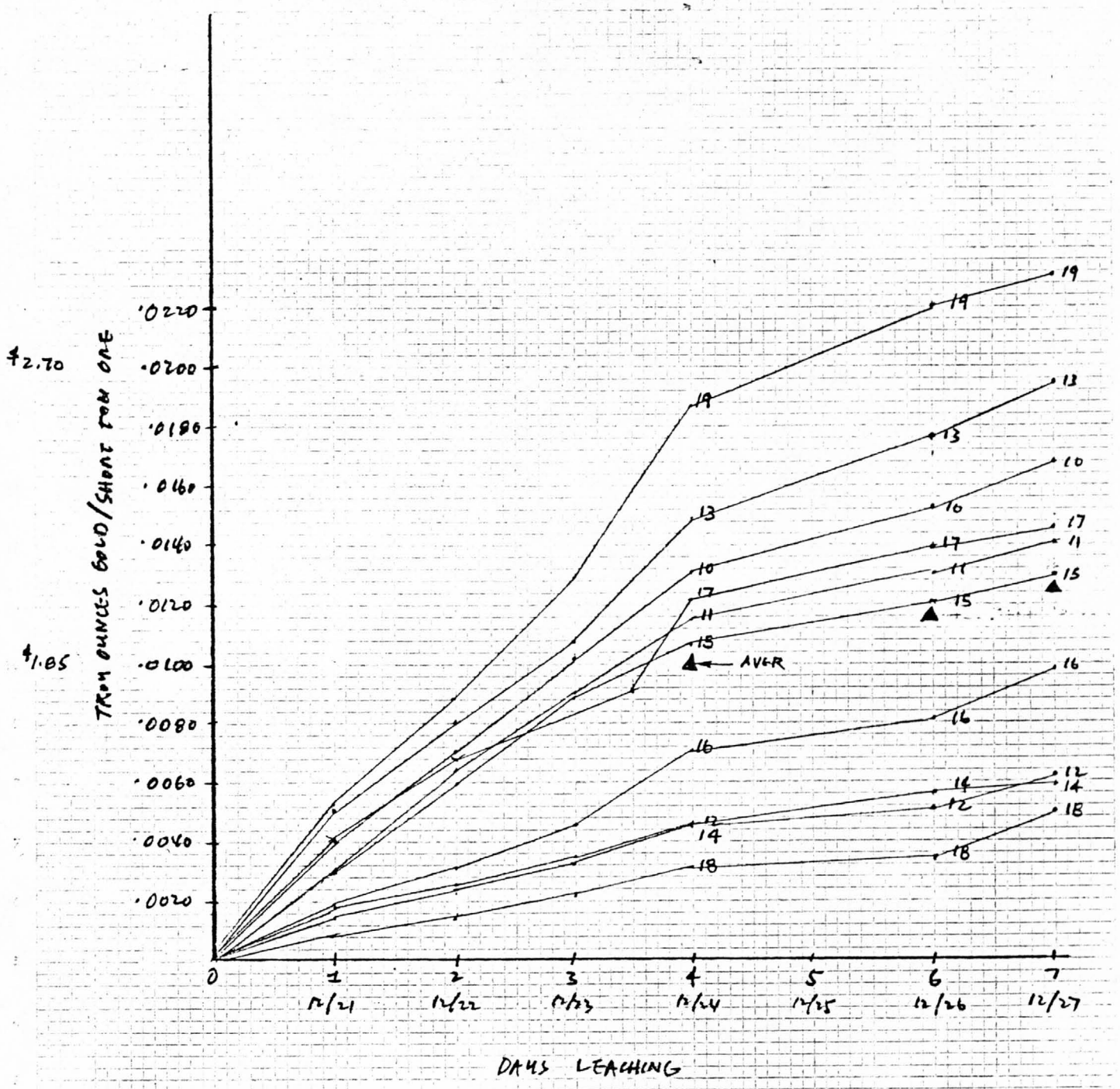


FIG. 1

TOMBSTONE BARREL TESTS 10-19

GOLD LEACHED 1/ IN TROY OUNCES/SHORT TON

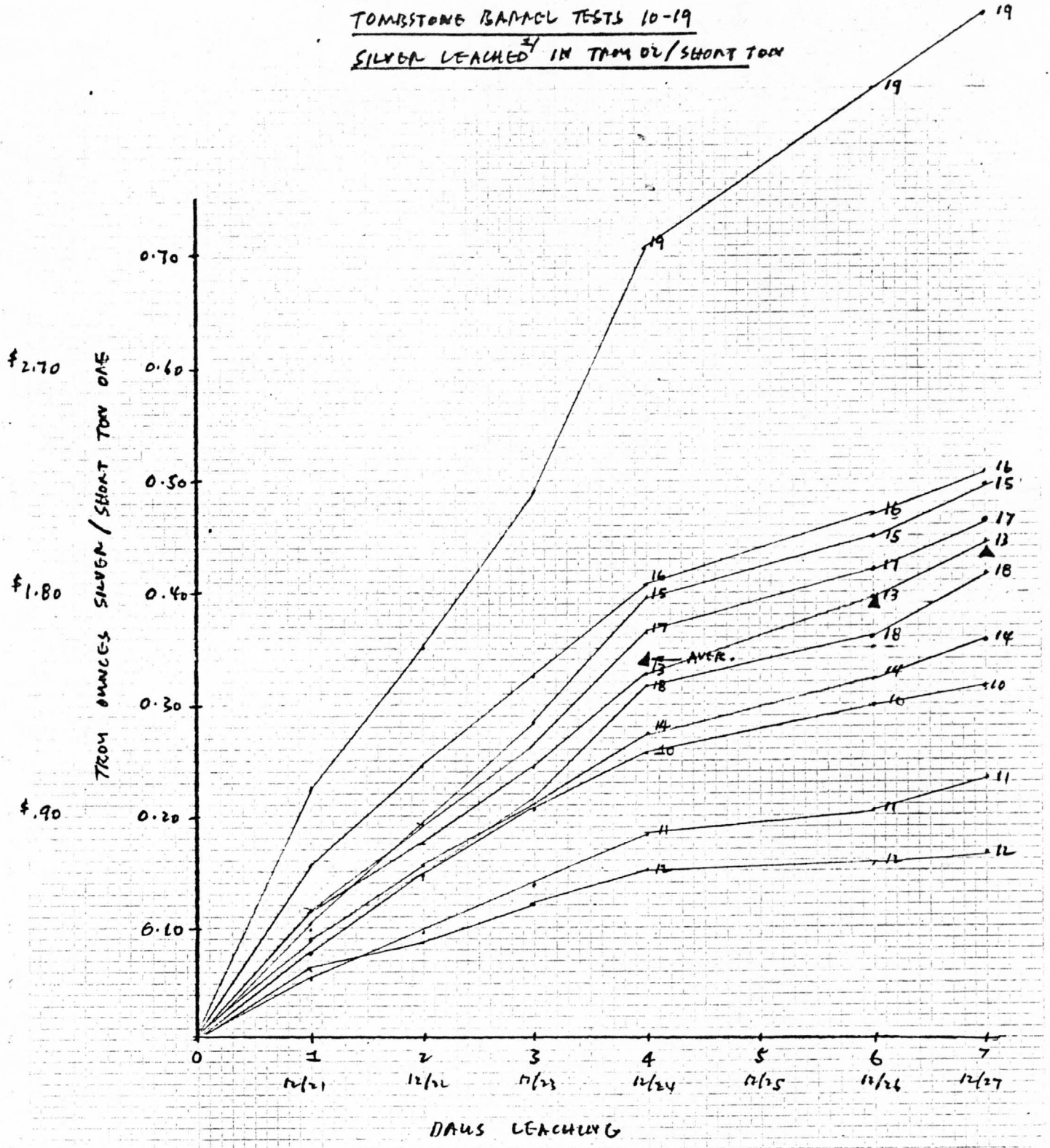


1/ FOR GOLD REMOVED ONLY, SEE FIG. 3, FOR GOLD IN TEST PLUS GOLD REMOVED, i.e. TOTAL GOLD LEACHED.

FIG. 2

TOMBSTONE BARREL TESTS 10-19

SILVER LEACHED 1/ IN TROY OZ/SHORT TON



1/ FOR SILVER REMOVED ONLY, SEE FIG. 4 FOR SILVER IN TEST. PLUS SILVER REMOVED, I.E. TOTAL SILVER LEACHED.

Barrel Tests: Summary of Reagents Consumption and Au & Ag Recovery

Test No.	Sample	Days Leaching	Reagents Consumption Lime/Ton	Reagents Consumption NaCN/Ton	Recovery, Au oz/Ton	Recovery, Au $/Ton	Recovery, Ag oz/Ton	Recovery, Ag $/Ton	Total $/Ton
1									
2									
3									
4									
5									
6									
7									
8									
9									
10	Tranquility	7	1.53	1.504	.0177	3.27	.332	1.33	4.60
11	Empire	7	1.35	1.488	.0150	2.78	.243	.97	3.75
12	Toughnut	7	1.88	1.544	.0066	1.22	.231	.92	2.14
13	Contention 1	7	1.53	2.359	.0212	3.92	.490	1.96	5.88
14	Little Joe	7	1.70	1.504	.0062	1.15	.386	1.54	2.69
15	West Side	7	1.21	1.496	.0135	2.50	.513	2.05	4.55
16	Grand Central	7	1.53	1.504	.0103	1.90	.537	2.15	4.05
17	Lucky Cuss	7	1.70	1.512	.0156	2.89	.499	2.00	4.89
18	Emerald	7	1.70	2.576	.0054	1.00	.454	1.82	2.82
19	Contention 2	7	1.00	1.504	.0247	4.57	.977	3.91	8.48
20	Toughnut	1			.0090	.00	.39		
21	Little Joe	1			.0050		.24		
22	Emerald	1			.0030		.48		
23	Bunker Hill	1			.0015		1.24		
24	Comet	1			.0038		.12		
25	St. of Maine	1			*.0362		.84		
26	Boss	1			.0227		.10		
27	Flora Mou.	1			.0082		.54		
28	Old Guard	1			.0265		.76		
29	Contention 2	1			.0191		.69		

Computations based on:
54 % available CaO
$185/oz Au, $4/oz Ag

For tests 10-19, lime consumption ≃ lime added. no titration data available

Barrel Tests: Summary of Reagents Consumption and Au & Ag Recovery

Test No.	Sample	Days Leaching	Reagents Cons. lb CaO/ton ore	lb NaCN/Ton ore	Recovery Au oz/T ore	$/T ore	Recovery Ag oz/T ore	$/T ore	Total $/T ore
30	Silver Thread	6	2.53	.976	.0136	2.52	.351	1.40	3.92
31	Contact	6	1.08	1.08	.0006	0.11	.057	0.23	0.34
32	Prompter	6	3.05	.992	.0020	0.37	.092	0.37	0.74
33	Hershel	6	3.27	1.40	.0050	0.92	.627	2.51	3.43
34	Bob Ingersol	6	3.01	1.35	.0124	2.29	2.141	8.56	10.85
35	Tribute	5	3.86	.944	.0033	0.61	.046	0.18	0.79
36	Sulpheret	5	3.99	.976	.0058	1.07	.026	0.10	1.17
37	Visina	6	3.05	.992	.0013	0.24	.847	3.39	3.63
38	Defense	6	2.52	1.496	.0017	0.31	.650	2.60	2.91
39	Tombstone Ext.	5	2.02	.984	nil	0	.009	0.04	0.04
40	Grand Dipper	5	2.70	.808	.0056	1.04	.141	0.56	1.60
41	Telephone	5	2.71	.832	.0002	0.04	.207	0.83	0.87
42	Silver Plume	5	2.95	.936	.0024	0.44	.261	1.04	1.48
43	Oregon	5	2.86	.928	.0004	0.07	.092	0.37	0.44
44	State of Maine	5	2.91	.928	.0002	0.04	.886	3.54	3.58
45	State of Maine underground	5	1.94	.952	nil	0	1.676	6.70	6.70
46	Tranquility	6	2.90	.968	.0128	2.37	.178	0.71	3.08
47	Tranquility	6	2.97	.968	.0119	2.20	.184	0.74	2.94
48	Contention	6	3.99	.984	.0152	2.81	.368	1.47	4.28
49	Contention	6	3.94	.984	.0150	2.78	.380	1.52	4.30
50	Lucky Cuss	6	3.01	.992	.0135	2.50	.453	1.81	4.31
51	Lucky Cuss	6	2.99	1.03	.0155	2.87	.463	1.85	4.72
52	Toughnut	5	3.94	.976	.0053	0.98	.244	0.98	1.96
53	Toughnut	5	3.94	.904	.0054	1.00	.212	0.85	1.85
54	Tombstone Ext.	5	2.93	.960	.0022	0.41	.123	0.49	0.90
55	Comet	5	2.97	.976	.0027	0.50	.101	0.40	0.90

Computations based on:
54% available CaO
$185/oz Au; $4/oz Ag

Test No.	SAMPLE	Days Leaching	Reagent Consumption			Au Recovery		Ag Recovery		Total
			lb lime per Ton	lb cacl2 per ton	lb NaCN per Ton	oz/Ton	$/Ton	oz/Ton	$/Ton	$/Ton
56	Contention 1	8	4.52	0	1.40	.0098	1.81	.159	.64	2.45
57	Contention 1	8	0	2.10	1.42	.0073	1.35	.104	.42	1.77
58	Contention 2	8	3.58	0	1.38	.0190	3.52	.588	2.35	5.87
59	Contention 2	8	0	1.04	1.40	.0195	3.61	.573	2.29	5.90

TEST 10

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location TRANQUILITY

Sample Weight, Lbs. 250

Total Days Leaching

December, 1974

Conducted by:

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	Oz % Rock Gold Recov.	% Silver Recov.
19	DEC-74	56.8	~~0~~	20,000	~~0~~	1.0							
20	DEC-74	30.0	56.8	2,000	0								
21	DEC-74	0	0	5000	5,000		.874	1.792	.082	14.04	306.8	.0036	.079
22	DEC-74	0	0	5,000	5,000		.096 / .970	1.562	.083	14.21	267.5	.0036 / .0072	.069 / .148
23	DEC-74	0	0	7,000	5,000		.037 / .957	1.360	.072	12.33	232.8	.0031 / .0103	.060 / .208
24	DEC-74	0	30.0	10,000	7,242		.008 / .960	.807	.044	10.91	200.1	.0028 / .0131	.051 / .259
26	DEC-74	0	0	10,000	7,752		.416 / 1.376	.567	.035	9.29	150.6	.0024 / .0154	.038 / .297
27	DEC-74	0	0	10,000	7,600		.088 / 1.464	.327	.021	5.46	85.1	.0014 / .0168	.021 / .318
28	DEC-74	0	0	0	8,680		.040 / 1.504	.186	.012	3.567	55.29	.0009 / .0177	.014 / .332
Total Ave.		86.8	86.8	69,000	46,474								

1 / 2

1 - Daily
2 - Cumulative

TEST 11

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location EMPIRE

Sample Weight, Lbs. 250

Total Days Leaching

Conducted by:

December, 1974

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	20,000	Ø								
20	DEC-74	10.Ø	56.8	2,000	Ø								
21	DEC-74	Ø	Ø	5000	5,000		.856	1.182	.078	13.356	203.42	.0034	.052
22	DEC-74	Ø	Ø	5,000	4,500		.080 / .936	1.130	.073	11.25	174.14	.0029 / .0063	.047 / .097
23	DEC-74	Ø	Ø	7,000	5,000		.024 / .960	.944	.059	10.10	161.64	.0026 / .0089	.042 / .139
24	DEC-74	10.Ø	30.Ø	10,000	7,242		.008 / .968	.662	.041	10.17	164.2	.0026 / .0115	.042 / .181
26	DEC-74	Ø	Ø	10,000	7,092		.384 / 1.352	.474	.028	6.80	115.1	.0017 / .0132	.029 / .210
17	DEC-74	Ø	Ø	10,000	7,400		.117 / 1.464	.330	.018	4.56	83.63	.0011 / .0143	.021 / .231
28	DEC-74	Ø	Ø	Ø	8,350		.024 / 1.488	.166	.010	2.860	47.47	.0007 / .0150	.012 / .243
Total Ave.		76.8	86.8	69,000	44,784								

1	2

1 - Daily
2 - Cumulative

TEST 12

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location TOUGHNUT

Sample Weight, Lbs. 250

Total Days Leaching

December, 1974

Conducted by:

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC-74	56.8	Ø	201000	Ø								
20	DEC-74	30.Ø	56.8	1,000	Ø								
21	DEC-74	Ø	Ø	5000	4800		.938	1.38	.042	6.90	236.30	.0018	.061
22	DEC-74	10.Ø	Ø	5,000	2,600		.048 / .976	1.127	.033	2.938	100.3	.0008 / .0026	.025 / .087
23	DEC-74	Ø	Ø	7,000	4,000		– / .976	.956	.028	3.836	130.9	.0010 / .0036	.034 / .121
24	DEC-74	10.Ø	30.Ø	10,000	6,942		– / .976	.689	.020	4.755	163.8	.0012 / .0048	.042 / .163
26	DEC-74	Ø	Ø	10,000	6,702		.460 / 1.416	.511	.014	3.213	117.3	.0008 / .0056	.030 / .193
27	DEC.-74	Ø	Ø	10,000	7,240		.120 / 1.536	.346	.010	2.49	85.78	.0006 / .0062	.022 / .215
28	DEC-74	Ø	Ø	Ø	8,390		.008 / 1.544	.213	.005	1.437	61.20	.0004 / .0066	.016 / .231
Total Ave.		106.8	86.8	68,000	40,874								

1 / 2

1 - Daily
2 - Cumulative

TEST 13

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location CONTENTION 1

Sample Weight, Lbs. 250

Total Days Leaching

December, 1974

Conducted by:

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC 74	56.8	~~0~~	20,000	~~0~~								
20	DEC-74	30.0	56.8	3,000	~~0~~								
21	DEC-74	0	0	5,000	4000		.944	2.59	.117	20.034	443.32	.0051	.114
22	DEC-74	0	30.0	5,000	3,000		.035 / .979	2.3085	.099	10.17	237.17	.0026 / .0071	.060 / .175
23	DEC-74	0	30.0	7,000	4,000		.488 / 1.464	1.929	.084	11.51	264.2	.0029 / .0107	.064 / .243
24	DEC-74	0	20.0	10,000	5,942		.437 / 1.896	1.622	.0715	14.55	330.1	.0037 / .0144	.085 / .328
26	DEC-74	0	0	10,000	6,952		.304 / 2.200	1.172	.051	12.14	279.0	.0031 / .0175	.072 / .400
27	DEC.-74	0	0	10,000	6,580		.175 / 2.375	.857	.035	2.88	193.11	.002 / .0195	.049 / .449
28	DEC-74	0	0	0	8,960		.034 / 2.409	.518	.021	6.444	158.9	.0017 / .0212	.041 / .490
Total Ave.		86.8	136.8	70,000	39.634								

1 / 2

1 - Daily
2 - Cumulative

TEST 14

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location LITTLE JOE

Sample Weight, Lbs. #250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	20,000	Ø								
20	DEC-74	30.Ø	56.8	2,000	Ø								
21	DEC-74	Ø	Ø	5,000	5000		.776	2.003	.032	5.479	342.98	.0014	.085
22	DEC-74	Ø	Ø	5,000	4,000		.160 / .936	1.843	.029	3.973	252.47	.0010 / .0024	.065 / .153
23	DEC-74	Ø	Ø	7,000	4,000		.032 / .968	1.659	.028	3.836	227.3	.0009 / .0034	.058 / .211
24	DEC-74	10.Ø	30.Ø	10,000	5,642		– / .968	1.235	.019	3.671	238.6	.0009 / .0043	.061 / .272
26	DEC-74	Ø	Ø	10,000	6,752		.368 / 1.336	.873	.015	3.468	201.9	.0009 / .0052	.051 / .323
27	DEC-74	Ø	Ø	10,000	6,610		.164 / 1.480	.588	.010	2.264	133.1	.0006 / .0058	.038 / .357
28	DEC-74	Ø	Ø	Ø	8,660		.024 / 1.504	.377	.005	1.483	111.8	.0004 / .0062	.029 / .386
Total Ave.		96.8	86.8	69,000	40,864								

1 / 2

1 - Daily
2 - Cumulative

Test - 36.041 250 lbs.

Test # 15

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location WEST SIDE

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	20,000	Ø	1.0 / 1.0	~~0~~ / 0					/	/
20	DEC. 74	Ø	56.8	4,000	Ø	0 / 1.0	1.0 / 1.0			-		/	/
21	DEC-74	Ø	Ø	5,000	5000	0 / 1.0	.880 / ~~1.0~~	↑	↑	↑	↑	/	/
22	DEC-74	Ø	Ø	5,000	5,000	0 / 1.0	.052 / .936	2.29	.068	11.64	392.29	.003 /	.101 /
23	DEC-74	Ø	Ø	7,000	5,000	0 / 1.0	.024 / .960	2.088	.065	11.13	357.5	.0029 / .0059	.0919 / .193
						/	/	2.054	.064	10.96	351.7	.0028 / .0087	.090 / .283
24	DEC-74	15.Ø	30.Ø	10,000	7,842	/	— / .960	1.665	.025	6.71	447.2	.0017 / .0104	.115 / .398
26	DEC-74	Ø	Ø	10,000	6,902	/	.416 / 1.376	.892	.026	6.15	210.8	.0016 / .0120	.054 / .452
27	DEC-74	Ø	Ø	10,000	7,650	/	.096 / 1.472	.585	.015	3.93	153.	.0010 / .0130	.039 / .491
28	DEC-74	Ø	Ø	Ø	8,850	/	.024 / 1.496	.280	.007	2.122	84.86	.0005 / .0135	.022 / .513
						/	/					/	/
Total Ave.		71.8	86.8	69,000	46,444								

1 / 2

1 - Daily
2 - Cumulative

TEST # 16

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location GRAND CENTRAL

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	18,500	Ø	1.0 / 1.0	0 / 0						
20	DEC-74	30.Ø	56.8	1,000	Ø	.53 / 1.53	1.0 / 0						
21	DEC-74	Ø	Ø	5,000	5000		.824	3.428	.042	7.19	586.98	.0018	.1508
22	DEC-74	Ø	Ø	5,000	3,800		.104 / .928	2.819	.040	5.205	366.9	.0013 / .0031	.094 / .245
23	DEC-74	Ø	Ø	7,000	4,000		.037 / .960	2.359	.035	4.794	323.2	.0012 / .0043	.083 / .328
24	DEC-74	Ø	30.Ø	10,000	6,798		.960	1.316	.042	9.778	305.8	.0025 / .0068	.079 / .407
26	DEC-74	Ø	Ø	10,000	6,762		.424 / 1.386	1.022	.017	3.937	236.7	.0010 / .0078	.061 / .468
27	DEC-74	Ø	Ø	10,000	6,470		.104 / 1.484	.693	.035	7.76	153.6	.0020 / .0098	.0395 / .507
28	DEC-74	Ø	Ø	Ø	8,900		.016 / 1.504	.387	.006	1.829	117.9	.0005 / .0103	.030 / .537
Total Ave.		86.8	86.8	66.5	41,930								

1 / 2

1 - Daily
2 - Cumulative

TEST # 17

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location LUCKY CUSS

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	20,000	Ø			PRE-CONDITIONED					
20	DEC-74	30.Ø	56.8	2,000	Ø			PRE-CONDITIONED					
21	DEC-74	Ø	Ø	5000	5000		.972	2.623	.091	15.58	449.14	.0040	.115
22	DEC-74	Ø	Ø	5,000	3,250		.052 / .968	2.578	.085	9.461	286.9	.0024 / .0064	.074 / .189
23	DEC-74	Ø	Ø	7,000	4000		.068 / .976	2.114	.075	10.27	289.6	.0026 / .0090	.074 / .263
24	DEC-74	10.Ø	30.Ø	10,000	6,848		– / .976	1.483	.052	12.20	347.8	.0031 / .0121	.089 / .352
26	DEC-74	Ø	Ø	10,000	6,412		.424 / 1.460	1.117	.034	7.47	245.3	.0019 / .0140	.063 / .415
27	DEC-74	Ø	Ø	10,000	6,940		.048 / 1.488	.789	.008	1.90	188	.0005 / .0145	.048 / .463
28	DEC-74	Ø	Ø	Ø	8,650		.024 / 1.512	.479	.014	4.147	141.9	.0011 / .0156	.036 / .499
Total Ave.		96.8	86.8	69,000	41.300								

1 / 2

1 - Daily
2 - Cumulative

TES # 18

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location EMERALD

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	20,000	Ø								
20	DEC-74	30.Ø	56.8	4000	Ø								
21	DEC-74	Ø	Ø	5,000	5000		.982	2.249	.019	3.25	385.1	.0008	.099
22	DEC-74	10.Ø	30.Ø	5,000	2,606		.040 / .992	2.003	.018	1.603	178.3	.0004 / .0012	.046 / .145
23	DEC-74	Ø	30.Ø	7,000	4,000		.488 / 1.480	1.927	.019	2.603	263.9	.0007 / .0019	.068 / .213
24	DEC-74	Ø	20.Ø	10,000	7,648		.336 / 1.816	1.533	.013	3.405	401.5	.0009 / .0028	.103 / .316
26	DEC-74	Ø	Ø	10,000	6,902		.488 / 2.304	.803	.009	2.127	189.8	.0005 / .0033	.049 / .365
27	DEC-74	Ø	Ø	10,000	8,250		.032 / 2.336	.727	.024	6.781	205.4	.0017 / .0050	.052 / .418
28	DEC-74	Ø	Ø	Ø	8,580		.024 / 2.576	.483	.005	1.469	141.9	.0004 / .0054	.036 / .454
Total Ave.		96.8	136.8	69,000	43.186								

1 / 2

1 - Daily
2 - Cumulative

TEST # 19 1.8/5 1.9

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location CONTENTION # II

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
19	DEC. 74	56.8	Ø	18200	Ø								
20	DEC. 74	Ø	56.8	Ø	Ø								
21	DEC. 74	Ø	Ø	5000	5000		.876	5.164	.122	20.89	884.24	.0053	.227
22	DEC-74	Ø	Ø	5,000	3,000		.120 / .936	4.6485	.1325	13.613	477.58	.0034 / .0088	.123 / .350
23	DEC-74	Ø	Ø	7,000	4,000		.018 / .944	3.980	.113	15.48	545.2	.0040 / .0128	.140 / .490
24	DEC-74	Ø	30.Ø	10,000	8,848		— / .944	2.812	.074	22.42	852.1	.0058 / .0186	.219 / .709
26	DEC-74	Ø	Ø	10,000	7,512		.457 / 1.400	2.153	.056	14.41	553.88	.0037 / .0223	.142 / .851
27	DEC. 74	Ø	Ø	10,000	6,390		.088 / 1.488	1.198	.012	2.63	262.2	.0007 / .0230	.067 / .918
28	DEC-74	Ø	Ø	Ø	8,990		.016 / 1.504	.749	.021	6.465	230.6	.0017 / .0247	.059 / .977
Total Ave.		56.8	86.8	65.200	43,940								

1 / 2

1 - Daily
2 - Cumulative

BECHTEL

Barrel Test 10-19 Assayed Screen Analysis, Tailings

		+1½	+1"	+½	+¼	-¼	Calc. Tailing	oz/ton leached	Calc. head	% Recovery
CONTENTION 1										
	wt %	6	4	13	17	60				
	Au	<.005	<.005	<.005	<.005	<.005	<.005	.0244	<.0244	83
TEST 13	Ag	0.72	2.76	0.62	0.78	1.16	1.063	.550	1.613	34
	wt x Au	—	—	—	—	—	—			
	wt x Ag	.0432	0.1104	.0806	.1326	.696	1.063			
	% Au	4	10	.8	13	65	100			
	% Ag	6	4	13	17	60	100			
CONTENTION 2										
	wt %	8	4	18	28	42				
	Au	<.005	<.005	<.005	<.005	<.005	<.005	0.0245	<.031	95
TEST 19	Ag	.80	.82	1.54	4.58	0.92	2.043	1.140	3.183	36
	wt x Au	—	—	—	—	—	—			
	wt x Ag	.064	.0328	.2772	1.2824	.3864	2.043			
	% Au	8	4	18	28	42	100			
	% Ag	3	2	13	63	19	100			
TRANQUILITY										
	wt %	19	9	20	19	33				
	Au	<.005	<.005	<.005	<.005	<.005	<.005	0.020	.025	80
TEST 10	Ag	.68	.60	.56	1.50	0.74	.8244	0.370	1.1944	31
	wt x Au	—	—	—	—	—				
	wt x Ag	.1292	.054	.112	.285	0.2442	.8244			
	% Au	19	9	20	19	33	100			
	% Ag	16	7	13	34	30	100			
Grand Central										
	wt %	18	5	17	17	43				
7	Au	<.005	<.005	<.005	.15 *	<.005	.0297	.0103	.0400	25
16	Ag	.30	.30	1.54	.35 *	.60	.649	0.60	1.245	48
	wt x Au									
	wt x Ag									
	% Au									
	% Ag									

BECHTEL

Barrel Tests 10-19, Crushed Tailing

		+ 1½"	+ 1"	+ ½	+ ¼	− ¼	Calc. tailing	oz/ton leached	Calc. head	% Recovery
Little Joe										
	wt%	11.0	5.0	15	18	51				
	Au	<.005*	<.005	<.005	<.005	.030*	.0179	.0077	.0256	30
Test 14	Ag	2.88*	.50	.54	.150	.30*	.603	0.44	1.043	42
	wt x Au	.0006	.0003	.0008	.0009	.0153	.0179			
	wt x Ag	.317	.025	.081	.027	.153	.603			
	% Au	3	2	4	5	85	100			
	% Ag	53	4	13	4	25	100			
West Side										
	wt%	23	9	22	17	29				
	Au	<.005	<.005	.056*	<.005*	<.005	.0164	.0154	.0318	48
Test 15	Ag	1.02	.82	1.14*	12.48*	1.32	3.06	0.57	3.63	16
	wt x Au	.0012	.0005	.0123	.0009	.0015	.0164			
	wt x Ag	.235	.024	.251	2.120	.383	3.063			
	% Au	7	3	75	5	9	100			
	% Ag	8	2	8	69	13	100			
Lucky Guss										
	wt%	15	6	18	17	44				
	Au	<.005	<.005	<.005	<.005	<.005*	<.0051	.0182	.0233	78
Test 1[illegible]	Ag	1.18	1.34	1.50	2.12	3.62*	2.480	0.56	3.04	18
	wt x Au	.0008	.0003	.0009	.0009	.0022	.0051			
	wt x Ag	.177	.080	.270	.360	1.593	2.480			
	% Au	15	6	18	17	44				
	% Ag	7	3	11	15	64				

* Aver. of duplicate assays

BECHTEL

Barrel Tests 10-19, Tailings

		+1 1/2	+1"	+1/2"	+1/4	-1/4	Calc. Tailing	or Ton Leached	Calc. Head	% Recovery
	Emerald									
	wt%	11	6	16	19	48				
Test 18	Au	.005	.005	<.005	.01	.005	.0060	.0046	.0106	43
	Ag	1.70	3.91	1.21	2.45	2.10	2.09	.47	2.56	18
	wt x Au	.0006	.0003	.0008	.0019	.0024	.0060			
	wt x Ag	.187	.235	.194	.466	1.008	2.09			
	% Au	10	5	13	32	40				
	% Ag	9	11	9	22	48				
	Empire									
	wt%	13	5	16	18	48				
TEST 11	Au	<.005	<.005	<.005	.040	.035	.0258	.0167	.0425	61
	Ag	1.50	2.04	0.78	3.12	2.45	2.160	.27	2.43	11
	wt x Au	.0007	.0003	.0008	.0032	.0168	.0258			
	wt x Ag	.195	.102	.125	.562	1.176	2.160			
	% Au	3	1	3	28	65	100			
	% Ag	9	5	6	26	54	100			
	Toughnut									
	wt%	11.0	5.0	17.0	18.0	49				
Test 12	Au	<.005	<.005	<.005	<.005	.010	.0076	.0070	.0146	48
	Ag	1.42	1.16	.70	.54	.79	.818	0.25	1.068	23
	wt x Au	.0006	.0003	.0009	.0009	.0049	.0076			
	wt x Ag	.156	.058	.119	.097	.387	.818			
	% Au	8	4	12	12	64	100			
	% Ag	19	7	15	12	47	100			

BECHTEL

1/7/75

183 (0501) 1-68

BARREL TESTS, 20-29
250# each

Started: 11:00 am 1/6/75

1/7/74

TEST	DUMP	ASCAN, SOLAR LOAT Au	Ag	ℓ in test	Mb/ton in 1 day Au	Ag	oz/ton in 1 day Au	Ag	$/ton Au	Ag
20	Tonghnut	.57	24.53	14	35.1	1512	.0090	.39	1.67	1.75
21	Little Joe	.38	17.86	15	19.52	917	.0050	.24	.93	1.06
22	Emerald	.18	28.62	19	11.71	1862	.0030	.48	.56	2.15
23	Bunker Hill	.08	64.00	22	6.03	4822	.0015	1.24	.29	5.58
24	Comet	.23	7.29	19	14.97	474	.0038	.12	.71	.55
25	St. of Maine	1.87	43.32	22	140.9	3264	.0362	.84	6.70	3.77
26	Boss	1.52	6.88	17	88.5	401	.0227	.10	4.21	.46
27	Flora Mow.	0.52	34.37	18	32.1	2119	.0082	.54	1.52	2.45
28	Old Guard	1.31	37.54	23	103.2	2957	.0265	.76	4.90	3.42
29	Cont. 2	1.36	49.12	16	74.5	2692	.0191	.69	3.54	3.11

Salt .002 Actual

#30 1,53

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Silver Thread

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	15,000	0		.816 / .816						
14	1-75	0	56.75	2000	0		.104 / .920						
15	1-75	0	0	6000	5000	1.78	.040 / .960	2.143	.078	13.3562	366.95	.0034	.094
16	1-75	0	0	6000	5,000	.13 / 1.91	.008 / .968	2.150	.083	14.2123	368.15	.0036 / .0070	.095 / .189
17	1-75	30.0	0	6000	5,000	— / 1.91	.008 / .976	1.653	.068	11.6438	283.05	.0030 / .0100	.073 / .262
18	1-75	0	0	6000	4300	.57 / 2.46	↓	.978	.044	6.4795	144.02	.0017 / .0087	.037 / .299
19	1-75	0	0	4000	4,550	.07 / 2.53	↓	.791	.031	4.8305	123.26	.0012 / .0099	.032 / .331
20	1-75	0	0		4220			.565	.019	2.7459	81.654	.0007 / .0106	.021 / .352
Total Ave.		143.50	56.75	45,000	28,070	2.86	0.36			53.3680	1367.08	.0137	.351

3.33 lb/T.N

1	2

1 - Daily
2 - Cumulative

@ 54% avail lime

#31

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contact

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	10,000	0								
14	1-75	0	56.75	2000	0								
15	1-75	0	0	5,000	2000	1.76	.824 / .824	.485	.020	0.1369	33.219	Nil	.008
16	1-75	0	0	5000	3200	.03 / 1.79	.140 / .964	.539	.010	0.1096	59.068	Nil	.015 / .023
17	1-75	0	0	5000	3800	.09 / 1.88	.056 / 1.02	.431	.010	1.3014	56.09	.0004 / .0004	.014 / .037
18	1-75	0	0	5000	3500	.06 / 1.94	.048 / 1.07	.294	.005	0.5993	35.24	.0002 / .0006	.009 / .046
19	1-75	0	0	4,000	3760	.03 / 1.97	.016 / 1.08	.215	TR	Nil	27.685	Nil / .0006	.007 / .053
20	1-75	—	—	—	3450			.141	TR	Nil	16.659	Nil / .0006	.004 / .057
Total Ave.										2.1478	227.96		

1 / 2

1 - Daily
2 - Cumulative

32

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Prompter

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	13,500	0		.952 / .952						
14	1-75	0	56.75	2000	0		.024 / .976						
15	1-75	0	0	5000	2500	1.98	.008 / .984	.761	.017	1.4555	65.154	.0004	.017
16	1-75	30.0	0	5000	3000	.01 / 1.99	.008 / .992	.740	.017	1.7466	76.027	.0004 / .0038	.020 / .027
17	1-75	30.0	0	5000	4000	.53 / 2.52		.658	.014	1.9178	90.137	.0005 / .0013	.023 / .060
18	1-75	0	0	5000	2600	.46 / 2.98		.442	.009	0.8014	39.356	.0002 / .0015	.010 / .070
19	1-75	0	0	4,000	3490	.07 / 3.05	.008 / .992	.402	.010	1.1952	48.047	.0003 / .0018	.012 / .082
20	1-75	—	—	—	3750			.309	.006	0.7705	39.683	.0002 / .0020	.010 / .092
		173.5											
Total Ave.										7.8870	358.40		

1 / 2

1 - Daily
2 - Cumulative

33

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Hershel ~~Silver Hill~~

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	15,000	0		.896 / .896						
14	1-75	56.75	56.75	2,000	0		.048 / .944						
15	1-75	0	0	5000	3000	.287	.024 / .968	5.105	.034	3.4932	524.486	.0009	.133
16	1-75	0	0	5000	2900	.07 / 2.94	.016 / .984	4.994	.047	4.6678	495.979	.0012 / .0021	.122 / .260
17	1-75	0	0	5000	3900	.03 / 2.97	.416 / 1.40	4.170	.038	5.0753	556.952	.0013 / .0034	.143 / .403
18	1-75	30.0	30.0	5000	2800	.03 / 3.00		2.845	.025	2.3973	272.808	.0006 / .0040	.070 / .473
19	1-75	0	0	4,000	3170	.27 / 3.27		2.819	.027	2.9312	306.035	.0007 / .0047	.079 / .552
20	1-75	—	—	—	3770			2.270	.012	1.5493	293.079	.0003 / .0050	.075 / .627
Total Ave.		200.25	86.75							20.1141	449.339	.0052	.624

1 / 2

1 - Daily
2 - Cumulative

#34

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Bob. Ingersol

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	14,500	0								
14	1-75	56.75	56.75	2,000	0								
15	1-75	0	0	6000	4600	2.96	.936 / .936	16.881	.111	17.4863	2659.336	.0045	.683
16	1-75	30.0	0	4000	3100	.03 / 2.99	.040 / .974	13.057	.086	9.1301	1386.188	.0023 / .0068	.356 / 1.039
17	1-75	30.0	0	6000	3900	.53 / 3.57	0 / .976	11.827	.030	4.0068	1579.634	.0010 / .0078	.406 / 1.445
18	1-75	0	30.0	5000	3800	.46 / 2.98	.008 / .984	7.834	.052	6.7671	1019.493	.0017 / .0095	.262 / 1.707
19	1-75	0	0	4000	3550	.03 / 4.01	.368 / 1.352	7.603	.050	6.0788	924.337	.0016 / .0111	.237 / 1.944
20	1-75				3760			5.956	.038	4.8932	766.937	.0013 / .0124	.197 / 2.141
Total Ave.		230.75								48.3623	8335.425		2.142

1 / 2

1 - Daily
2 - Cumulative

#35 Tribute

~~Trubat~~

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location ~~Stubent~~

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	Ø	15,000	Ø								
14	1-75	56.75	Ø	2,000	Ø								
15	1-75	56.75	56.75	2,000	Ø								
16	1-75	Ø	Ø	5000	4350	3.70	.792	.322	.030	4.464	47.969	.0011	.012
17	1-75	Ø	Ø	6000	3800	.06 / 3.76	.072 / .864	.325	.027	3.5137	42.2945	.0009 / .0020	.011 / .023
18	1-75	Ø	Ø	5000	4050	.04 / 3.80	.040 / .904	.268	.018	2.4966	37.171	.0006 / .0026	.009 / .032
19	1-75	Ø	Ø	4000	3250	.06 / 3.86	.040 / .944	.247	.015	1.9264	31.721	.0005 / .0031	.008 / .040
20	1-75	—	—	—	3350			.207	.009	1.0325	23.748	.0002 / .0033	.006 / .046
Total Ave.		127.0								13.4382	182.983	.0034	.047

1 / 2

1 - Daily
2 - Cumulative

#36

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Sulphuret

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	15,000	0								
14	1-75	56.75	0	3,000	0								
15	1-75	56.75	56.75	2,000	0								
16	1-75	0	0	5000	2,000	3.89	.896	.227	.056	3.8356	15.548	.0010	.004
17	1-75	0	0	6000	4100	– / 3.89	0 / .896	.217	.055	7.7226	30.4691	.0020 / .0030	.008 / .012
18	1-75	0	0	5000	3850	.06 / 3.95	.048 / .944	.153	.036	4.7466	20.173	.0012 / .0042	.005 / .017
19	1-75	0	0	4000	3680	.04 / 3.99	.032 / .976	.142	.033	4.1589	17.896	.0010 / .0052	.005 / .022
20	1-75	—	—	—	3600			.111	.021	2.5890	13.685	.0006 / .0058	.004 / .026
Total Ave.										23.0527	97.771	.0059	.025

1 / 2

1 - Daily
2 - Cumulative

#37

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Visina

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	15,000	0								
14	1-75	0	56.75	2,000	0								
15	1-75	0	0	5,000	3500	1.85	.904 / .904	7.659	.013	1.5582	918.03	.0004	.236
16	1-75	30.0	0	5000	2350	.13 / 1.98	.044 / .968	6.524	.011	0.8853	525.05	.0002 / .0006	.135 / .371
17	1-75	30.0	0	6000	4700	.52 / 2.50	— / .968	5.233	.009	1.4486	842.298	.0004 / .0010	.216 / .587
18	1-75	0	0	5000	2900	.00 / 2.90	.024 / .992	3.475	.006	0.5959	345.120	.0001 / .0011	.088 / .676
19	1-75	0	0	4000	3350	.15 / 3.05	— / .992	2.802	.004	0.4589	321.462	.0001 / .0012	.083 / .759
20	1-75	—	—	—	4672			2.142	.002	0.3200	342.72	.0001 / .0013	.088 / .847
Total Ave.										5.2669	3294.68	.0014	

1 / 2

1 - Daily
2 - Cumulative

38

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Defense

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
13	1-75	113.5	0	13,000	0								
14	1-75	0	56.75	2,000	0								
15	1-75	0	0	6,000	5,000	1.79	.808	4.706	.015	2.5685	805.82	.0006	.207
16	1-75	30.0	30.0	5000	4350	.15 / 1.94	.120 / .928	3.917	.012	1.7877	583.53	.0004 / .0010	.150 / .357
17	1-75	0	0	6000	4350	.40 / 2.34	.360 / 1.288	3.207	.011	1.6387	477.76	.0004 / .0014	.123 / .480
18	1-75	0	0	5000	4500	.12 / 2.46	.112 / 1.40	1.959	.006	0.9247	301.90	.0002 / .0016	.078 / .558
19	1-75	0	0	4000	4,000	.06 / 2.52	.096 / 1.496	1.511	.004	0.5479	206.986	.0001 / .0017	.053 / .611
20	1-75	—	—	—	4042			1.105	.001	0.1384	152.959	Nil / .0017	.039 / .650
Total Ave.										7.6059	2528.955	.0020	.650

1 / 2

1 - Daily
2 - Cumulative

#39 Tomb. Extension

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Tombstone Extension

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	Ø	29,000	Ø								
21	1-75	Ø	1400 HRS 56.75	10,000	Ø								
22	1-75	Ø	Ø	Ø	3670		–	.062	TR	Nil	7.792	Nil	.002
23	1-75	Ø	Ø	3000	2590	1.76	.848 / .848	.118	.001	.0887	10.466	Nil	.003 / .005
24	1-75	Ø	Ø	3000	3270	.24 / 2.00	.136 / .984	.048	.001	.1120	5.735	Nil	.001 / .006
25	1-75	Ø	Ø	7700	1760			.074	.001	.0602	4.460	Nil	.001 / .007
26	1-75	—	—	—	2900			.092	.001	.0993	9.137	Nil	.002 / .009
Total Ave.										.3602	37.590	nil	.010

1 / 2

1 - Daily
2 - Cumulative

#40 Ground Dropper

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	~~0~~	15,000	~~0~~								
21	1-75	56.75	1400 56.75	~~0~~	~~0~~								
22	1-75	~~0~~	~~0~~	7000	6760		–	.693	.034	7.8712	160.434	.0020	.041
23	1-75	~~0~~	~~0~~	6000	5790	2.67 / 2.67	.688 / .688	.705	.026	5.1555	139.793	.0013 / .0033	.036 / .077
24	1-75	~~0~~	~~0~~	5,000	4730	.07 / 2.70	.120 / .808	.507	.017	5.6647	168.942	.0014 / .0047	.043 / .120
25	1-75	~~0~~	~~0~~	6000	3840			.345	.014	1.8411	45.370	.0005 / .0052	.011 / .131
26	1-75	—	—	—	5500			.211	.008	1.5069	39.743	.0004 / .0056	.010 / .141
Total Ave.										22.0394	554.282	.0057	.142

1 / 2

1 - Daily
2 - Cumulative

41 Telephone

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	~~0~~	15,000	~~0~~								
21	1-75	56.75	1400 56.75	~~0~~	~~0~~								
22	1-75	~~0~~	~~0~~	6000	3440	~~.02~~ —	.816 .816	1.527	.002	0.2356	179.893	.00006	.046
23	1-75	~~0~~	~~0~~	5000	5,000	2.68	.016 .837	1.142	.001	0.1712	195.548	.00004 .0001	.050 .096
24	1-75	~~0~~	~~0~~	5.000	8000	.03 2.71	— .837	.911	.001	0.2740	249.589	.00007 .00017	.064 .160
25	1-75	~~0~~	~~0~~	6000	3950			.725	.001	0.1353	98.074	.00003 .0002	.025 .185
26	1-75	—	—	—	4850			.509	TR	—	84.543	Nil .0002	.022 .207
Total Ave.										.8161	807.647	.0002	.208

1 / 2

1 - Daily
2 - Cumulative

42 Silver Plume

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	Ø	16,000	Ø								
21	1-75	56.75	56.75	3,000	Ø								
22	1-75	Ø	Ø	6000	5150	–	–	1.393	.016	2.8219	245.683	.0007	.063
23	1-75	Ø	Ø	6,000	5700	2.9 / 2.9	.904 / .904	1.223	.010	1.9521	238.736	.0005 / .0012	.061 / .124
24	1-75	30	Ø	5.000	9700	.03 / .95	.03 / .936	1.064	.010	3.3219	353.452	.0008 / .0020	.091 / .215
25	1-75	Ø	Ø	6000	3310			.770	.008	0.9068	87.284	.0002 / .0022	.022 / .237
26	1-75	—	—	—	4200			.655	.006	0.8630	94.212	.0002 / .0024	.024 / .261
Total Ave.										9.8657	1019.367	0025	.262

1	2

1 - Daily
2 - Cumulative

43 OREGON

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	-0-	15,000	-0-								
21	1-75	56.75	1400 56.75	-0-	-0-								
22	1-75	-0-	-0-	6000	3200	—	.920 / .920	.503	.003	0.3288	55.123	.0001	.014
23	1-75	∅	∅	7000	6946	2.70	— / .920	.449	.003	0.7136	106.807	.0002 / .0003	.027 / .041
24	1-75	∅	∅	5000	11860	.16 / 2.86	.008 / .924	.330	.001	0.4062	134.034	.0001 / .0004	.034 / .075
25	1-75	-0-	-0-	6000	4150			.249	Tr	Nil	35.388	Nil / .0004	.009 / .084
26	1-75	—	—	—	4856			.197	.001	0.1661	32.721	Nil / .0004	.008 / .092
Total Ave.										1.6147	364.074	/	.094

1 / 2

1 - Daily
2 - Cumulative

44 State of Maine Re Run

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	Ø	16,000	Ø								
21	1-75	56.75	1400 56.75	7,000	Ø								
22	1-75	Ø	Ø	7000	7150	2.52	.597	4.096	.001	0.2449	1002.959	.0001	.258
23	1-75	Ø	Ø	8000	5,800	.10 / 2.66	.286 / .872	3.710	.001	0.1986	736.918	.0001 / .0002	.189 / .447
24	1-75	Ø	Ø	5000	7680	.25 / 2.91	.052 / .928	3.1695	.0005	0.1315	833.622	Nil / .0002	.214 / .661
25	1-75	Ø	Ø	14,000	3480			2.236	Tr	Nil	266.482	Nil / .0002	.068 / .729
26	1-75	—	—	—	12,600			1.412	Tr	Nil	609.288	Nil / .0002	.157 / .886
Total Ave.										.5750	3449.269	.0001	/

1 / 2

1 - Daily
2 - Cumulative

#45 State of Maine
under ground

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location _____

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	1-75	113.5	ø	21,000	ø								
21	1-75	ø	1400 56.75	8,000	ø								
22	1-75	ø	ø	8000	8460	1.90	.872	7.474	TR	Nil	2165.412	Nil	.556
23	1-75	ø	ø	8000	7300	.03 / 1.93	.072 / .944	6.3715	.0005	0.1250	1592.875	Nil	.409 / .965
24	1-75	30	ø	5000	12210	.01 / 1.94	.008 / .952	3.392	TR	Nil	1476.449	Nil	.379 / 1.344
25	1-75	ø	ø	15,000	3820			3.598	TR	Nil	470.70	Nil	.121 / 1.465
26	1-75	—	—	—	11,000			2.181	TR	Nil	821.610	Nil	.211 / 1.676
Total Ave.										.1250	6527.045	nil	1.677

1 / 2

1 - Daily
2 - Cumulative

46

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location *Tranquility*

Sample Weight, Lbs. *250 Dry*

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	Ø	16,000	Ø								
30	1-75	56.75	56.75	1000	Ø								
31	1-75	Ø	Ø	7000	5260	2.61	.720	1.527	.089	16.8319	275.07	.0041	.070
1	2-75	Ø	Ø	6000	5772	.10 / 2.71	.136 / .856	.949	.068	13.4416	187.59	.0035 / .0076	.050 / .120
2	2-75	Ø	Ø	6000	5210	.14 / 2.89	.088 / .944	.559	.043	7.6722	99.382	.0020 / .0096	.026 / .146
3	2-75	Ø	Ø	7000	4675	.01 / 2.90	.024 / .968	.376	.032	5.1233	60.1986	.0013 / .0109	.015 / .161
4	2-75	Ø	Ø	6000	10,270	— / 2.90	— / .968	.148	.015	5.2757	52.054	.0014 / .0123	.013 / .174
5	2-75	Ø	Ø	Ø	5410			.104	.012	2.2232	19.268	.0005 / .0128	.004 / .178
Total Ave.										49.7679	693.543		

1 / 2

1 - Daily
2 - Cumulative

47

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Tranquility

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	Ø	15,006	1000								
30	1-75	56.75	56.75	1000	Ø								
31	1-75	Ø	Ø	6000	4800	2.65	.736	1.671	.1020	16.7671	274.685	.0043	.071
1	2-75	Ø	Ø	6000	5100	.13 / 2.78	.120 / .856	1.108	.074	12.9247	193.521	.0033 / .0076	.050 / .121
2	2-75	Ø	Ø	5000	4,400	.10 / 2.88	.072 / .928	.663	.045	6.7808	99.904	.0017 / .0093	.026 / .147
3	2-75	Ø	Ø	5000	4310	.06 / 2.94	.032 / .960	.462	.033	4.8709	68.192	.0013 / .0106	.02 / .167
4	2-75	Ø	Ø	5000	3850	.03 / 2.97	.008 / .968	.282	.022	2.9007	37.182	.0007 / .0113	.010 / .177
5	2-75	Ø	Ø	Ø	4000			.195	.018	2.4657	26.3123	.0006 / .0119	.007 / .184
Total Ave.										46.7099	700.1963	.0120	.180

1 / 2

1 - Daily
2 - Cumulative

48

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	Ø	21,000	Ø								
30	1-75	56.75	56.75	4,000	Ø								
31	1-75	Ø	Ø	11,000	9760	– / –	.808	1.961	.071	23.7315	655.458	.0061	.168
1	2-75	Ø	Ø	9000	8220	2.67	.088 / .896	1.143	.050	14.0753	321.762	.0036 / .0097	.083 / .251
2	2-75	56.75	Ø	6000	5850	.33 / 3.00	.080 / .976	.882	.040	8.0136	176.702	.0021 / .0118	.045 / .296
3	2-75	Ø	Ø	5000	5000	.98 / 3.98	– / .976	.231	.035	5.9932	125.171	.0015 / .0133	.032 / .328
4	2-75	Ø	Ø	6000	4100	.01 / 3.99	.008 / .984	.569	.028	3.9315	79.894	.0010 / .0143	.021 / .349
5	2-75	Ø	Ø	–	5000			.439	.022	3.7671	75.171	.0009 / .0152	.019 / .368
Total Ave.										59.5177	1434.158	.0153	/

1 / 2

1 - Daily
2 - Cumulative

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	ø	21,000	ø								
30	1-75	56.75	56.75	2,000	ø								
31	1-75	ø	ø	8000	6550	2.47	.872	2.013	.076	17.0479	451.546	.0044	.116
1	2-75	ø	ø	8000	7150	.42 / 2.89	.056 / .928	1.610	.065	15.9161	394.229	.0041 / .0085	.101 / .217
2	2-75	56.75	ø	6000	6250	.10 / 2.99	.056 / .984	1.195	.047	10.0599	255.779	.0026 / .0111	.066 / .283
3	2-75	ø	ø	6000	5170	.94 / 3.93	– / .984	1.007	.041	7.2592	178.294	.0019 / .0130	.046 / .329
4	2-75	ø	ø	6000	4580	.01 / 3.94	– / .984	.729	.029	4.5486	114.343	.0011 / .0141	.029 / .358
5	2-75	ø	ø	–	4220			.585	.023	3.3323	84.544	.0009 / .0150	.022 / .380
Total Ave.										58.1440	1478.735	.0149	

1 / 2

1 - Daily
2 - Cumulative

50

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Lucky Cuss

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	ø	17,000	ø								
30	1-75	56.75	56.75	2,000	ø								
31	1-75	ø	ø	6,000	4400	2.73	.840	3.368	0.101	15.2192	507.507	.0039	.130
1	2-75	ø	ø	6000	4470	.21 / 2.94	.117 / .957	2.687	.082	12.5527	411.332	.0032 / .0071	.106 / .236
2	2-75	ø	ø	6000	4250	.01 / 2.95	.008 / .960	1.960	.058	8.4417	285.273	.0021 / .0092	.073 / .309
3	2-75	ø	ø	6000	5530	.06 / 3.01	.037 / .997	1.553	.047	8.9010	294.113	.0023 / .0115	.076 / .385
4	2-75	ø	ø	6000	4710	— / 3.01	— / .997	1.023	.030	4.8390	165.011	.0012 / .0127	.042 / .427
5	2-75	ø	ø	—	4350			.027	.023	3.4263	100.830	.0008 / .0135	.026 / .453
Total Ave.										53.3799	1764.066	.0137	1

1 / 2

1 - Daily
2 - Cumulative

Lucky Cuss (A)

51

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Lucky Cuss

Sample Weight, Lbs. 250 Dry

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	0	17,000	0								
30	1-75	56.75	56.75	1,000	0								
31	1-75	0	0	10,000	8620	2.80	.776	2.205	.073	21.5500	650.928	.0055	.167
1	2-75	0	0	10,000	9050	.06 / 2.86	.144 / .920	1.548	.052	16.1164	479.774	.0041 / .0096	.123 / .290
2	2-75	0	0	6000	9350	.01 / 2.87	— / .920	1.093	.035	10.0085	312.553	.0026 / .0122	.080 / .370
3	2-75	0	0	6000	4400	.118 / 2.99	.117 / 1.03	.946	.031	4.6712	142.548	.0012 / .0134	.037 / .407
4	2-75	0	0	6000	6360	— / 2.99	— / 1.03	.610	.021	4.5740	132.863	.0012 / .0146	.034 / .441
5	2-75	0	0	—	5250			.431	.013	3.3476	84.921	.0009 / .0155	.022 / .463
Total Ave.										60.2677	1803.533	/	/

1 / 2

1 - Daily
2 - Cumulative

Lucky Cuss B

52

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Toughnut

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	-0-	15,000	-0-								
30	1-75	56.75	56.75	-0-	-0-								
31	1-75	-0-	-0-	6000	4780	2.72	.760	2.088	.044	7.2027	341.803	.0018	.088
1	2-75	-0-	-0-	6000	4580	.10 / 2.82	.096 / .856	1.575	.034	5.3329	247.038	.0014 / .0032	.063 / .151
2	2-75	56.75	-0-	5000	4500	.169 / 2.99	.120 / .976	1.182	.030	4.6232	182.152	.0012 / .0044	.047 / .198
3	2-75	-0-	-0-	6000	3000	.95 / 3.94	— / .976	.831	.017	1.7466	85.377	.0004 / .0048	.022 / .220
4	2-75	-0-	-0-	6000	5250	— / 3.94	— / .976	.520	.011	1.9777	93.493	.0005 / .0053	.024 / .244
Total Ave.										20.8831	949.868	0.054	—

1	2

1 - Daily
2 - Cumulative

Toughnut A

53

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Toughnut

Sample Weight, Lbs. 250 Dry

Total Days Leaching

December, 1974

Conducted by:

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	0	15000	0								
30	1-75	56.75	56.75	0	0								
31	1-75	0	0	7000	4940	2.73	.752	1.753	.046	7.7822	296.569	.0020	.076
1	2-75	0	0	6000	4670	.11 / 2.84	.032 / .784	1.326	.035	5.5976	212.069	.0014 / .0034	.054 / .130
2	2-75	56.75	0	5000	4650	.16 / 3.00	.120 / .904	.964	.024	3.8219	153.513	.0010 / .0044	.039 / .169
3	2-75	0	0	6000	3000	.94 / 3.94	— / .904	.798	.018	1.8493	81.986	.0005 / .0049	.021 / .190
4	2-75	0	0	5000	4830	— / 3.94	— / .904	.510	.012	1.9850	84.360	.0005 / .0054	.022 / .212
Total Ave.										21.036	828.497	/	.213

1 / 2

1 - Daily
2 - Cumulative

Test 8

54

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Tombstone Ext.

Sample Weight, Lbs. 250 DRY

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	0	19,000	0								
30	1-75	0	56.75	1000	0		~~.84~~						
31	1-75	0	0	6000	3600	1.90	.896	.831	.016	1.9726	102.452	.0005	.026
1	2-75	0	0	6000	3120	.07 / 1.97	.056 / .952	.9015	.0185	1.9767	96.325	.0005 / .0010	.025 / .051
2	2-75	56.75	0	5000	4650	.060 / 1.98	— / .952	.716	.012	1.9109	114.020	.0004 / .0014	.029 / .080
3	2-75	0	0	6000	3700	.95 / 2.93	.014 / .960	.670	.011	1.3938	84.897	.0004 / .0018	.022 / .102
4	2-75	0	0	5000	4720	— / 2.97	— / .961	.496	.010	1.6164	80.175	.0004 / .0022	.021 / .123
Total Ave.										8.8704	477.869	.0023	-

1 / 2

1 - Daily
2 - Cumulative

Tombstone Extension

55

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Comet

Sample Weight, Lbs. 250 Dry

Total Days Leaching

December, 1974

Conducted by:

Approved by:

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
29	1-75	113.5	0	17,000	0								
30	1-75	56.75	56.75	1,000									
31	1-75	0	0	6000	Removed overflow 2000 3525	2.97	.917	0.800	.021	2.5351	96.575	.0007	.075
1	2-75	0	0	6000	3640	.04 / 2.96	.037 / .944	0.700	.021	2.6178	87.260	.0007 / .0014	.022 / .047
2	2-75	0	0	5000	4250	— / 2.94	.016 / .960	.577	.015	2.183	81.070	.0005 / .0019	.021 / .068
3	2-75	0	0	5000	4800	.01 / 2.97	.008 / .968	.493	.013	2.1370	81.041	.0005 / .0024	.021 / .089
4	2-75	0	0	5000	3870	— / 2.97	.008 / .976	.362	.009	1.1928	47.977	.0003 / .0027	.012 / .101
Total Ave.										10.6659	393.923		

1 / 2

1 - Daily
2 - Cumulative

56

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention 1-A

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	3/75	113.5	0	15,000	0								
21	3/75	60.0	0	3,000	0								
24	3/75	30.0	56.75	6000	3177			.883	.0575	6.2560	96.07	.0016	.025
25	3/75	0	0	↓	↓	3.07	.936	↓	↓	↓	↓	↓	↓
26		0	0	6500	4260	.57 / 3.54	– / .936	.872	.055	8.0240	127.22	.0021 / .0037	.033 / .058
27		0	0	7000	5130	.06 / 4.00	– / .936	.625	.044	7.7301	109.45	.0020 / .0057	.028 / .086
28		0	0	7000	5750	– / 4.00	.016 / .952	.433	.028	5.5137	85.26	.0014 / .0071	.022 / .108
1	4/75	30.0	0	8000	6250	– / 4.00	.040 / .992	.374	.022	4.3774	80.05	.0011 / .0082	.021 / .129
2		0	0	6000	5810	.52 / 4.52	– / .992	.278	.016	3.1836	55.31	.0008 / .0090	.014 / .143
3		0	30	7000	5130	– / 4.52	.008 / 1.00	.217	.012	2.1082	38.12	.0005 / .0095	.010 / .153
4					5180	– / 4.52	.40 / 1.40	.144	.007	1.2417	25.54	.0003 / .0098	.006 / .159
Total Ave.		233.5	86.75	65500	40,687					38.4347	617.02	.0099	.158

1 / 2

1 - Daily
2 - Cumulative

57

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention 1-B

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS ~~CaO~~ Caustic Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	3/75	to pH 10-11	0	15,000	0								
21	3/75	60.0	0	1,000	0								
24	3/75	30.0	56.75	4000	2292			.688	.049	3.8461	54.00	.0010	.014
25		0	0	↓	↓	1.57	.616	↓	↓	↓	↓	↓	↓
26		0	0	5000	2650	– / 1.57	.304 / .920	.730	.057	5.1730	66.25	.0013 / .0023	.017 / .031
27		0	0	5000	3560	– / 1.57	.008 / .928	.605	.046	5.6082	73.76	.0014 / .0037	.019 / .050
28		0	0	5000	3670	– / 1.57	.024 / .952	.472	.035	4.399	59.32	.0011 / .0048	.015 / .065
1	4/75	30.0	0	6000	3970	– / 1.57	.032 / .984	.432	.0295	4.0108	58.76	.0010 / .0058	.015 / .080
2	"	0	0	5000	3890	.53 / 2.10	– / .984	.295	.020	2.6644	39.30	.0007 / .0065	.010 / .090
3		0	30	6000	3650	– / 2.10	.048 / .944	.242	.016	2.0000	30.25	.0005 / .0070	.008 / .098
4					3890	– / 2.10	.032 / 1.024	.172	.010	1.3082	22.50	.0003 / .0073	.006 / .104
Total Ave.		1.20 +	86.75	52000	27502					29.0097	404.14	.0074	–

1 / 2

1 - Daily
2 - Cumulative

58

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention 2-A

Sample Weight, Lbs. 250

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS CaO Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	3/75	113.5	0	15,000	0								
21	3/75	60.0	0	0	0								
24	3/75	30.0	56.75	6000	5052			3.586	.081	14.0141	620.43	.0036	.159
		0	0	↓	↓	3.06	.736	↓	↓	↓	↓	↓	↓
		0	0	5000	4350	.37 / 3.43	.104 / .840	3.088	.090	13.0849	460.03	.0034 / .0070	.118 / .277
		0	0	5000	3560	.15 / 3.58	.072 / .912	2.451	.086	10.4849	298.82	.0023 / .0096	.077 / .354
28		0	0	6000	3950	– / 3.58	.024 / .936	1.858	.068	9.1986	251.34	.0024 / .0120	.064 / .418
1	4/75	0	0	7000	5290	– / 3.58	.048 / .984	1.428	.051	9.2394	258.70	.0024 / .0144	.066 / .484
2	"	0	0	5000	4700	– / 3.58	– / .984	1.067	.048	7.7260	171.74	.0019 / .0163	.044 / .528
3		0	30	8000	4090	– / 3.58	.008 / .992	.811	.038	5.3226	113.60	.0014 / .0177	.029 / .557
4					6300	– / 3.58	.384 / 1.376	.562	.023	4.9623	121.25	.0013 / .0190	.031 / .588
Total Ave.		203.5	86.75	57000	37,265					74.0328	2295.91		.590

1 / 2

1 - Daily
2 - Cumulative

59

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention 2-B

Sample Weight, Lbs. 250 lbs

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS ~~CaO~~ Caustic Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Lime #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
20	3/75	pH 10-11	0	15,000	0								
21	3/75	30.0	0	1,000	0								
24	3/75	30.0	56.75	8000	6152			2.90	.069	14.5372	610.99	.0037	.157
25		0	0	↓	↓	.418	.656	↓	↓	↓	↓	↓	↓
26		0	0	7500	6510	.53 / 1.02	.184 / .840	2.468	.083	18.5044	550.23	.0048 / .0085	.141 / .298
27		0	0	7000	5710	– / 1.04	.076 / .916	1.804	.067	13.1017	352.77	.0034 / .0119	.091 / .389
28		0	0	8000	5620	– / 1.04	.024 / .940	1.229	.049	9.4308	236.54	.0024 / .0143	.061 / .449
1	4/75	0	0	8000	6770	– / 1.04	.016 / .956	.852	.033	7.6510	197.54	.0020 / .0163	.051 / .500
2		0	0	7000	6460	– / 1.04	.008 / .964	.571	.028	6.1945	126.32	.0016 / .0179	.032 / .532
3		0	30	8000	5810	.02 / 1.04	– / .964	.368	.018	3.5815	73.22	.0009 / .0188	.019 / .551
4					6810	– / 1.04	.432 / 1.396	.373	.013	3.0318	86.99	.0008 / .0196	.022 / .573
Total Ave.		60 +	86.75	69500	49,842					76.0379	2234.60	.0195	.574

1 / 2

1 - Daily
2 - Cumulative

02 = 3.60
.6 = 2.40
6.00

60

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention II

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS ~~CaO~~ NaOH Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption ~~Lime~~ NaOH #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
9	4-75	60.0	~~0~~	15,000	~~0~~								
10	4-75		56.75		—			—	—	—	—		
11		30.0		5000	3750	1.06	.192	4.631	.147	18.878 ~~4.631~~	594.73	.0048	.153
14				5000	3400	.34 / 1.40	.112 / .904	3.822	.132	15.3699	445.03	.0039 / .0087	.114 / .267
15				5000	3440	.15 / 1.55	.032 / .936	3.114	.108	12.7233	366.85	.0033 / .0120	.094 / .361
16				5000	3590	— / 1.55	.024 / .960	2.328	.081	9.2586	286.77	.0026 / .0146	.074 / .435
18				0	3500	— / 1.55	.024 / .984	1.843	.061	7.3116	221.03	.0019 / .0165	.057 / .492
Total Ave.													

1 / 2

1 - Daily
2 - Cumulative

61

TOMBSTONE HEAP LEACH

METALLURGICAL TESTS

Dump Location Contention II

Sample Weight, Lbs. _____

Total Days Leaching _____

December, 1974

Conducted by: _____

Approved by: _____

Date Day	Date Month/Yr	GMS ~~CaO~~ NaOH Added	GMS NaCN Added	cc Water Added	cc Water Removed	Reagent Consumption Na2CO4 ~~Lime~~ #/Ton Ore	Reagent Consumption NaCN #/Ton Ore	Solution Assays Silver Oz/Ton	Solution Assays Gold Oz/Ton	MG. Gold Leached	MG. Silver Leached	% Gold Recov.	% Silver Recov.
9	4-75	60.0	56.75	15,000	~~0~~								
10	4-75			–	4840	.784	.672	3.510	0.142	24.0233	593.82	.0062	.153
11				5000	3240	.24 / 1.04	.216 / .888	3.230	.136	15.0904	358.40	.0038 / .0100	.092 / .245
14				5000	3330	– / 1.04	.054 / .944	2.770	.113	12.8866	315.89	.0033 / .0133	.081 / .326
15				5000	2840	– / 1.04	.034 / .976	2.204	.092	8.9479	214.36	.0023 / .0156	.055 / .381
16				5000	2990	– / 1.04	.016 / .992	1.713	.071	7.2702	175.41	.0019 / .0195	.045 / .426
18					3150	.02 / 1.06	– / .992	1.333	.053	5.7175	143.80	.0015 / .0190	.037 / .463
Total Ave.													

1 / 2

1 - Daily
2 - Cumulative

GEOLOGIC DESCRIPTION OF THE PRINCIPAL

DUMPS, TOMBSTONE DISTRICT, ARIZONA

Mine - Dump	Principal* Rock Types		CU Oxides	Mn Oxides	Sulfates	Sulfides	Remarks
Lucky Cuss	Arg., Ls., Monz.		xxx	xxxx	xx	xx	Some trash & carbon on s
Oregon	Ls.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Prompter	Ls.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Telephone	Ls.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Bunker Hill	Ls.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Rattlesnake	Ls.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Comet	Ls., Monz.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Black Eagle	Ls. Monz.	Not sampled	-	xxxx	-	-	Not samp.-produced Mn o
Emerald	Ls., qtzt.		xxxx	xxx	xxx	xxx	Copper oxides and wulfe ite abundant
Silver Plume	Ls., qtzt.		xx	xxx	xx	xx	
Luck Sure	Ls.	Not sampled	-	xxx	-	-	
State of Maine	Latite porph.		x	xxx	x	-0-	Contains some trash & t

Abbreviations: Ls=limestone, Arg=argillaceous quartzite, Monz=intermediate igneous intrusive rock, Novac=fine grained quartzite, qtzt=quartzite

* Rock types listed in order of decreasing amounts generally present in dump

(x = very rare) (xx = rare) (xxx = common) (xxxx = abundant)

GEOLOGIC DESCRIPTION OF THE PRINCIPAL

DUMPS, TOMBSTONE DISTRICT, ARIZONA

Mine - Dump	Principal* Rock Types		CU Oxides	Mn Oxides	Sulfates	Sulfides	Remarks
Empire	Arg., Ls., Monz		xxx	x	x	xx	
Tranquility	Arg., Monz., Ls.		xxx	x	x	x	Fluorite & wulfenite, some rotted timber
Toughnut	Arg., Ls., Novac.		xxx	xx	xx	xx	Some timber expected
Visina	Novac., Ls.	Not sampled	-	-	-	-	Very siliceous
Westside	Arg., Ls., Novac.		xxx	xx	x	xx	East ½ only is ours
Silver Thread	Arg., Ls., Novac.	Not sampled	-	-	-	-	Probably similar to the Westside
Boss	Arg., Monz.	Not sampled	-	-	-	-	Probably similar to the Westside
Defence	Novac., Arg., Monz.	Not sampled	-	-	-	-	Probably similar to the Westside
Tribute	Arg., Ls., Monz.	Not sampled	-	-	-	-	Probably similar to the Westside
Contention	Arg., Monz.		xxx	x	xxx	xxx	Lots of carbon and trash in and on the dumps
Grand Central	Arg., Monz.		xxx	x	xxx	x	
Little Joe	Arg., Monz.		xxx	x	xxx	x	
Arizona Queen	Arg.	Not sampled	-	-	-	-	Probably similar to Tranq.
Sulphuret	Arg., Monz.	Not sampled	-	-	-	-	Probably similar to Tranq.

COMPILATION

PAST SAMPLING PROGRAMS (Austral Oil)

Mine Dumps	Tons		Au oz/ton		Ag oz/ton	
Boss #1	3,400	0.030	0.037	.001	2.39	.072
Bunker Hill #1	15,300	0.134	0.030	.004	3.59	.481
Bunker Hill #2	10,500	0.091	0.007	.001	3.10	.282
Emerald #2	1,600	0.014	0.020	-	2.10	.029
Empire #1	41,000	0.358	0.080	.029	1.90	.680
Herschedl #1	6,800	0.059	0.015	.001	3.47	.205
Lucky Cuss #1	18,200	0.159	0.040	.006	2.98	.474
Oregon #1	1,000	0.009	0.005	-	5.52	.050
Oregon #2	1,500	0.013	0.002	-	3.27	.043
Prompter #1	1,600	0.014	0.005	-	3.65	.051
Rattlesnake	3,000	0.026	0.005	-	2.33	.061
San Pedro	1,500	0.013	0.005	-	4.48	.058
Tranquility #1	9,200	0.080	0.060	.005	3.22	.258
	114,600	1.001		0.047		2.74

Weighted averages

Au 0.047 oz/ton	@ $100.00	-	$ 4.70
Ag 2.47 oz/ton	@ $3.00	-	7.41
	Value per ton		$12.11

EFFECT OF CRUSHING

Note that the values(Au & Ag) are generally evenly distributed between the coarse and the fines. Therefore, crushing of the coarse would be economical.

EFFECT OF SCREENING
TOMBSTONE DUMPS

Dump No.	Unscreened		Screened					
			-3/4 inch			-1/4 inch		
	Au	Ag	Wgt.%	Au	Ag	Wgt.%	Au	Ag
Empire								
41-1	.046	.68	85	.050	.72	60	.055	.64
41-2	.026	1.27	78	.022	1.29	55	.020	1.35
41-3	.057	1.29	72	.060	1.23	40	.070	1.31
41-4	.010	.24	84	.015	.28	58	-	.30
41-5	.025	1.66	84	.027	1.52	59	.030	1.80
41-6	.065	3.58	76	.091	3.34	50	.045	4.80
41-7	.063	.94	73	.078	0.83	48	.055	.87
41-8	.047	.93	74	.054	1.07	46	.035	1.16
41-9	.031	.50	59	.040	.60	32	.060	.62
41-10	.029	2.10	74	.030	2.42	50	.030	2.95
41-11	.026	.68	78	.031	0.72	52	.040	.76
41-12	.051	.62	74	.063	0.64	48	.040	.74
41-13	.018	.45	75	.016	0.39	50	.020	.41
41-14	.039	1.61	75	.029	1.30	46	.025	.44
41-15	.027	.83	62	.033	0.90	36	.045	1.16

EMPIRE

Sample	Total Tons	Unscreened Tons	Unscreened Au	Unscreened Ag	Screened Tons	Screened Au	Screened Ag
41-1	4,500	4,500	.046	.678	3,915	.049	.715
2	3,500	3,500	.026	1.267	595	.039	1.302
3	2,500	2,500	.067	1.290	2,500	.067	1.290
4	Waste	-	-	-	-	-	-
5	6,800	6,800	.025	1.66	6,800	.025	1.66
6	3,600	3,600	.065	3.58	3,600	.065	3.58
7	1,835	1,835	.063	.940	1,835	.063	.940
8	3,420	3,420	.047	.930	2,770	.052	0.979
9	2,000	2,000	.031	.497	640	.060	.62
10	5,000	5,000	.029	2.098	4,050	.030	2.34
11	4,000	4,000	.026	.685	3,320	.030	.73
12	1,000	1,000	.051	.621	810	.059	.61
13	Waste	-	-	-	-	-	-
14	1,500	1,500	.039	1.611	810	.051	2.61
15	1,500	1,500	.027	0.826	540	.045	1.16
		41,155	.039	1.416	32,185	.044	1,582

EFFECT OF SCREENING
TOMBSTONE DUMPS

Dump No.	Unscreened		Screened					
			-3/4 inch			-1/4 inch		
	Au	Ag	Wgt.%	Au	Ag	Wgt.%	Au	Ag
Contention								
38-1	.035	.93						
38-2	.009	.73	75	.006	.92	49	.005	1.06
38-3	.010	.21						
38-4	.023	.56	66	.025	.58	40	.040	.64
38-5	.041	1.92	64	.048	2.31	40	.050	1.61
38-6	.010	.23						
38-7	.027	1.21	76	.031	1.34	48	.045	1.76
38-8	.014	.86	66	.017	.97	40	.015	1.09
38-9	.027	.96	67	.038	1.37	39	.055	1.88
38-10	.005	.80	68	.006	.49	41	.010	.81
38-11	.030	1.89	46	.015	1.18	41	.030	1.89
38-12	.015	1.37	67	.019	1.02	41	.020	1.14
38-13	.002	.30	59	.002	.25	33	.005	.46
38-14	.016	.68	85	.025	1.03	33	.040	1.30

EFFECT OF SCREENING
TOMBSTONE DUMPS

Dump No.	Unscreened		Screened					
			-3/4 inch			-1/4 inch		
	Au	Ag	Wgt.%	Au	Ag	Wgt.%	Au	Ag
Toughnut								
39-1	.050	5.90	78	.058	6.89	51	.085	8.64
39-2	.018	1.85	75	.019	2.13	46	.025	2.80
39-3	.015	1.36	76	.015	1.46	47	.020	1.64
39-4	.003	1.36	64	-	1.00	38	.007	1.01
39-5	.003	1.31	69	-	1.39	39	.008	1.58
39-6	.040	2.10						
39-7	.017	2.69	71	.024	3.18	33	.030	2.18
39-8	.015	1.92	74	.019	2.17	34	.035	3.99
39-9	.010	.63						
39-10	.006	.94	49	.014	2.00	24	.025	3.54
39-11	.009	1.13	80	.011	1.29	55	.015	1.70
39-12	.015	1.38	53	.023	1.32	33	.030	1.71
39-13	.022	1.93	64	.030	2.42	38	.035	3.20
39-14	.002	.26	42	.006	.37	22	.005	.61
39-15	-	.62	46	-	.75	32	-	.84
39-16	-	.43	21	-	.38	9.5	-	.34

TRANQUILITY

Sample	Total Tons	Unscreened Tons	Unscreened Au	Unscreened Ag	Screened Tons	Screened Au	Screened Ag
40-1	2,000	2,000	.045	1.83	1,240	.055	2.53
2	2,000	2,000	.023	.564	Waste	-	-
3	2,500	2,500	.045	1.687	1,525	.060	2.19
4	1,500	1,500	.011	1.702	1,100	.010	2.13
5	4,000	4,000	.061	1.420	4,000	.061	1.42
6	1,500	1,500	.028	.898	2,120	.090	1.64
7	3,000	3,000	.005	.680	Waste	-	-
8	Waste	-	-	-	Waste	-	-
9	3,000	3,000	.064	2.91	1,290	.108	5.85
10	1,500	1,500	.021	.954	525	.050	1.75
11	2,000	2,000	.017	2.197	1,180	.010	2.18
12	2,000	2,000	.070	0.40	1,316	.088	.458
13	6,500	6,500	.087	2.17	6,500	.087	2.166
		31,500	.049	1.590	20,796	.070	2.101

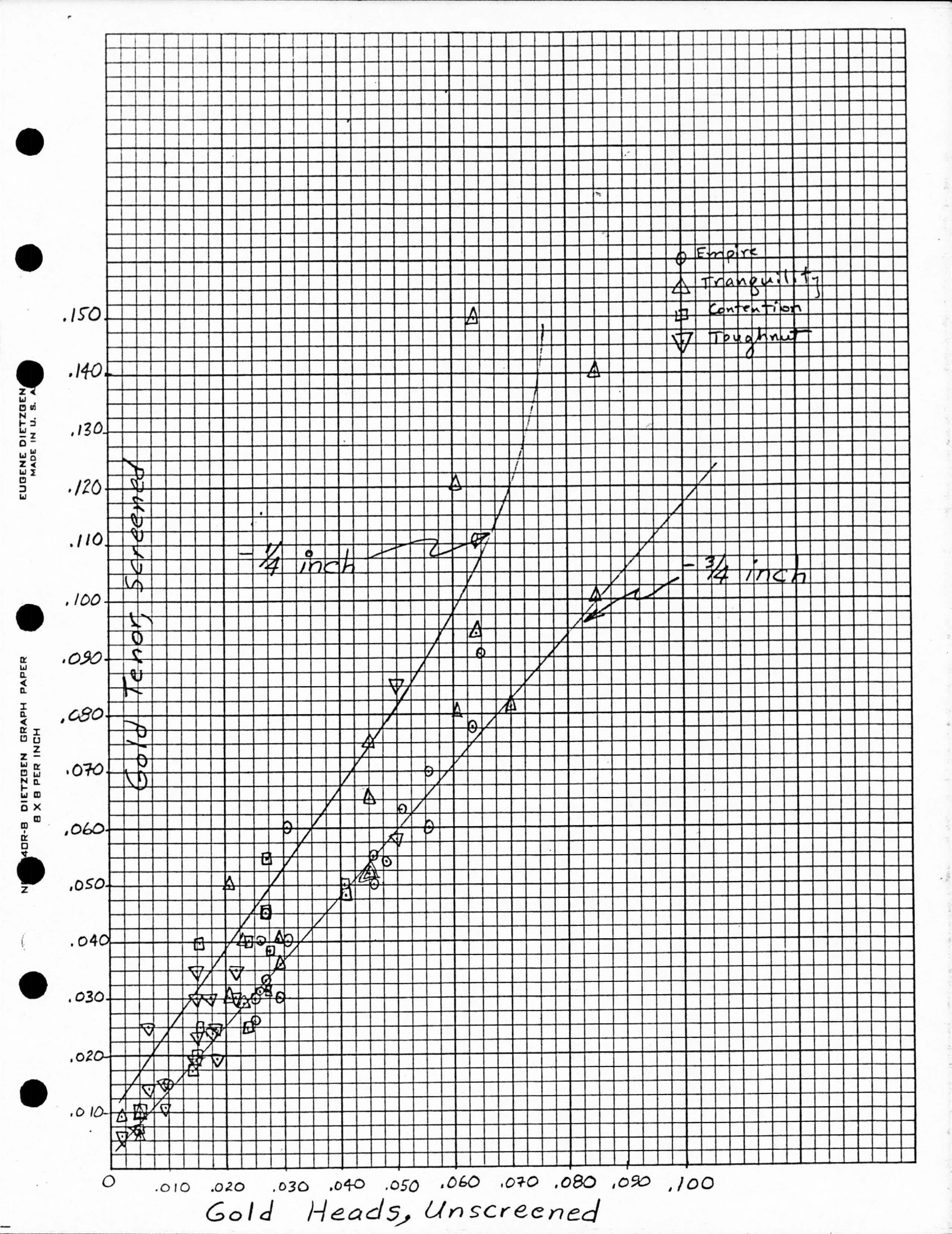
SIERRA MINERAL MANAGEMENT

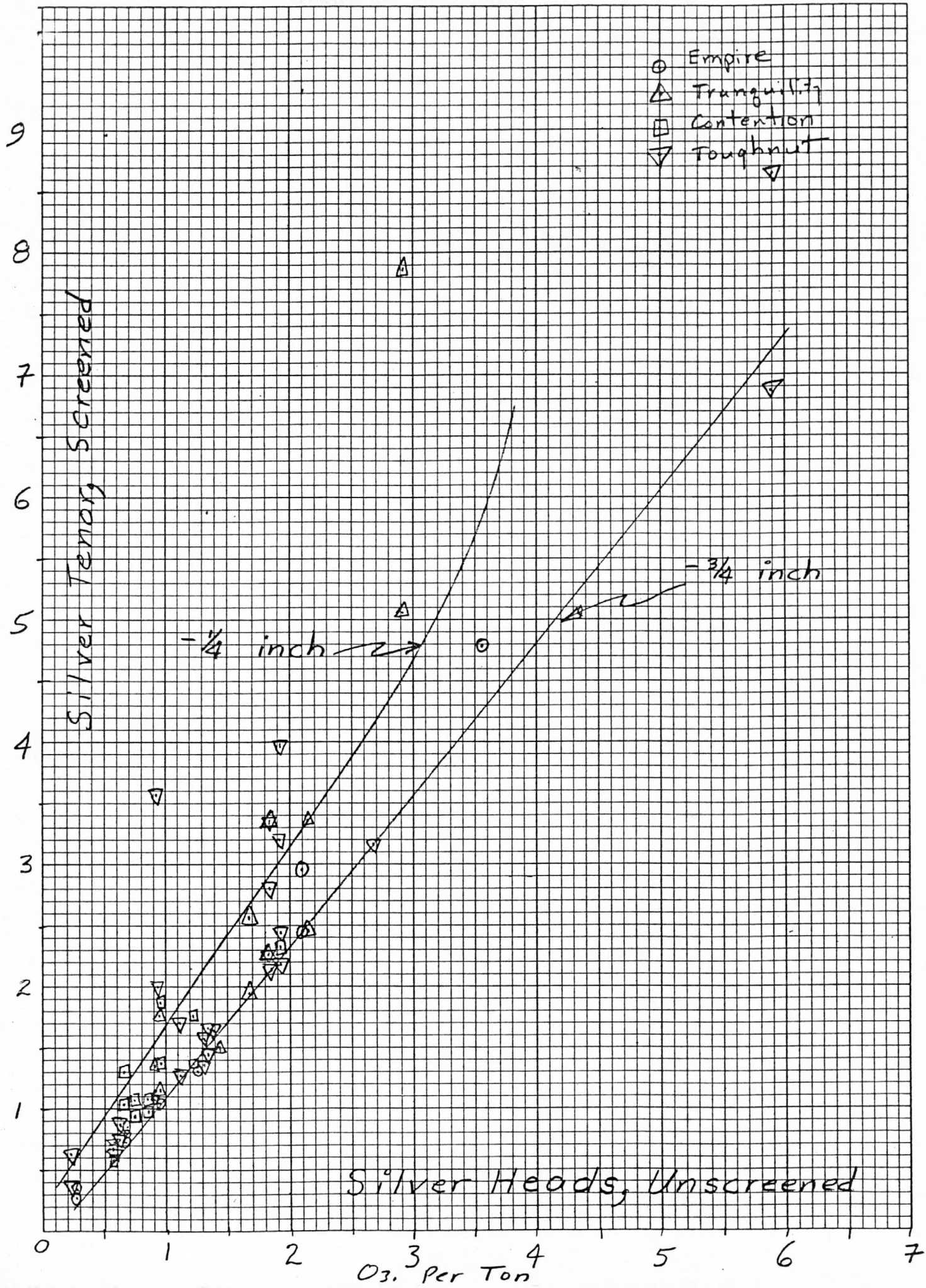
R. F. HEWLETT
President

4741 EAST SUNRISE DRIVE
SKYLINE BEL AIRE PLAZA
TUCSON, ARIZONA 85718
602 / 299-9736

State of Maine- Brother Jonathan Dump

Sample No.	Tons	Au	Ag
J-1	2500	0.0138	2.6271
M-1	1700	0.0130	2.9867
M-2	1600	0.0090	3.9579
M-3	1500	0.0051	2.0187
M-4	500	---	2.7862
M-5	500	0.0072	3.0912
M-6	1000	---	3.6436
M-7	1000	0.0032	3.5445
M-8	1000	---	2.55
M-9	1000	---	3.57
M-10	1000	---	1.96
	13,300	.006	2.95


Empire
Tranquility
Contention
Toughnut
-1/4 inch
-3/4 inch
Gold Tenor, Screened
Gold Heads, Unscreened
0
.010
.020
.030
.040
.050
.060
.070
.080
.090
.100
.110
.120
.130
.140
.150
EUGENE DIETZGEN
MADE IN U. S. A.
NO. 340R-B DIETZGEN GRAPH PAPER
8 X 8 PER INCH



EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

TOMBSTONE
PRODUCTION SCHEDULE
(450 tons per day)

Time	Dump	Grade Au	Grade Ag	Recovered Value 95% Au, 75% Ag: $130/$3.50 Per Ton	Recovered Value 95% Au, 75% Ag: $130/$3.50 Per Month
March '74	Lucky Cuss	.039	2.91	$12.46	$155,750
April	Lucky Cuss	.039	2.91	12.46	155,750
May	Lucky Cuss	.039	2.91	12.46	155,750
June	Lucky Cuss	.039	2.91	12.46	155,750
July	Herschel	.015	3.47	10.96	137,000
Aug.	Oregon, Prompt., Boss	.018	3.25	10.75	134,375
Sept.	Tranquility	.049	1.59	10.23	127,875
Oct.	Tranquility	.049	1.59	10.23	127,875
Nov.	Tranquility	.049	1.59	10.23	127,875
Dec. '76	Tranq./Empire	.046	1.53	9.70	121,250
Jan. '75	Empire	.039	1.42	8.54	106,750
Feb.	Empire	.039	1.42	8.54	106,750
March	Empire	.039	1.42	8.54	106,750
April	Emp./Toughnut	.033	2.65	11.03	137,875
May	Toughnut	.027	2.82	10.74	134,250
June	Contention	.042	1.45	9.00	112,500
July	Contention	.042	1.45	9.00	112,500
Aug.	Contention	.042	1.45	9.00	112,500
Sept.	Contention	.042	1.45	9.00	112,500
Oct.	Cotention	.042	1.45	9.00	112,500
Nov.	Little Joe	.050	2.20	11.95	149,375
Dec. '75	Little Joe	.051	2.23	12.15	151,875
Jan. '76	Silver Thread	.030	2.22	9.53	119,125
Feb.	Bunker Hill	.021	3.39	11.49	143,625
March	Bunker Hill	.021	3.39	11.49	143,625
April	BH/San Pedro/St. M.	.008	3.53	10.25	128,125
May	St. Maine/Ingersol	.011	2.43	7.74	96,750
June	Comet/Defence	.028	1.78	8.13	101,625
July	Defence/Emerald	.025	1.93	8.15	101,875
Aug.	Emerald	.025	1.75	7.68	96,000
Sept.	Emerald	.025	1.75	7.68	96,000

PRODUCTION SCHEDULE

Dump	Total Tonnage	Segregated or Screened Au	Ag	Tonnage
Lucky Cuss	50,000	.039	2.91	50,000
Herschel	10,000	.015	3.47	10,000
Oregon	5,000	.003	4.17	5,000
Prompter	4,000	.005	3.63	4,000
Boss	5,000	.037	2.39	5,000
Tranquility	45,000	.049	1.59	45,000
Empire	45,000	.039	1.42	45,000
Toughnut	50,000	.027	2.82	20,000
Contention	127,800	.042	1.45	65,000
Little Joe	20,000	.051	2.23	20,000
Silver Tread	16,000	.030	2.22	16,000
Bunker Hill	25,800	.021	3.39	25,800
San Pedro	2,000	.005	4.48	2,000
State of Maine	15,000	.006	2.95	15,000
Ingersol	12,000	.017	1.71	5,000
Comet	15,000	.030	1.56	6,000
Defence	26,000	.025	2.01	11,000
Emerald	55,000	.025	1.75	38,000
Old Guard	20,000	.020	1.49	14,000
Rattlesnake	5,000	.010	2.80	3,000
Silver Plume	25,000	.014	1.03	11,000
Sulphuret	6,000	.043	1.05	3,000
West Side	60,000	.019	1.62	42,000
	644,600	.032	2.07	460.800

SIERRA METALS

R. F. HEWLETT
President

4741 EAST SUNRISE DRIVE
SKYLINE BEL AIRE PLAZA
TUCSON, ARIZONA 85718
602/299-9736

TOMBSTONE

METAL PRICE SENSITIVITY ANALYSIS

FOR HEAP LEACHING VS. MILLING

Assume:

1. Rate of mining for heap leaching is 45,000 tons-per-month
2. Heap leaching extraction percentages are 60% Au and 50% Ag
3. Heap leaching cost of production = $3 per ton
4. Rate of milling is 12,500 tons-per-month
5. Milling extraction percentages are 75% for Au and Ag
6. Milling cost of production = $7.50 per ton
7. Base prices are $170 Au and $4 Ag

Extraction Method	Recv. Au	Ext. Time	Au Month	Recv. Ag	Ext. Time	Ag Month
Heap Leach	11,239	12.6 ms.	892	550,602	12.6 ms.	43,699
Mill (H.L.)	3,938	16.8 ms.	234	505,439	16.8 ms.	30,086
H.L. & Mill	15,177	13.$\bar{5}$ ms.	1126	1,056,041	14.$\bar{3}$ ms.	73,785
Mill Only	14,999	64 ms.	234	1,313,901	64 ms.	20,530

Gold Price Change

$4 Ag - Monthly Net Profit Before Tax

Ext. Method	Gross Value Ag/Mo	Production Costs/Mo	Monthly Net	Au Gross Value		Au NPBT	
				$150	$200	$150	$200
Heap Leach	$174,796	$135,150	$39,646	$133,800	$178,400	$173,446	$218,046
Mill (H.L.)	120,344	93,754	26,590	35,100	46,800	61,690	73,390
H.L. & Mill	295,140	228,904	66,236	168,900	225,200	235,136	291,436
Mill Only	82,120	93,743	−11,623	35,100	46,800	23,477	35,177

R. F. HEWLETT
President

4741 EAST SUNRISE DRIVE
SKYLINE BEL AIRE PLAZA
TUCSON, ARIZONA 85718
602/299-9736

From the above, notice the advantage of both heap leaching and milling. Comparisons of heap leaching and milling vs. milling follows:

	Heap Leaching & Milling	Milling Only
Tons Processed	567,631 + 210,009 = 799,940	799,940
Extraction Time	Less than 2 years	Over 5 years
Recovered Au	15,702 t. ounces	16,999 t. oz.
Recovered Ag	1,056,041 t. ounces	1,313,902 t. oz.
Gross Sales	$7,331,868	$8,668,641
Production Costs	$3,256,960	$5,919,556
Net Profit B. Tax	$4,074,908	$2,749,085
Av.Mon. Net Profit B.T.	$ 169,788 (2 yrs.)	$ 45,818 (5 yrs.)
Depletion, Total	$1,022,795	$1,209,275
Depletion, Yearly	$ 511,398 (2 yrs.)	$ 241,855

Utilization of the heap leaching method of gold-silver extraction in combination with the milling of the high-grade manganese ores minimizes the risks involved with using only ore extraction method, such as milling.

Evaluating the variables (risks) results as follows:

	Heap Leaching	Mill
Break-even Extraction Rate (Dec. 5)	23%	53%
Break-even Precious Metal Prices		
Gold (H.L. %=60/50; Mill %=85/75)	$54	$193
Silver (Same; Gold=60 & 85, Silver=50 & 75)	$ 2	$ 2

The graphical presentation is shown on the following page.

SIERRA METALS

R. F. HEWLETT
President

4741 EAST SUNRISE DRIVE
SKYLINE BEL AIRE PLAZA
TUCSON, ARIZONA 85718
602/299-9736

SUMMARY COMPARISON OF

MILLING AND HEAP LEACHING

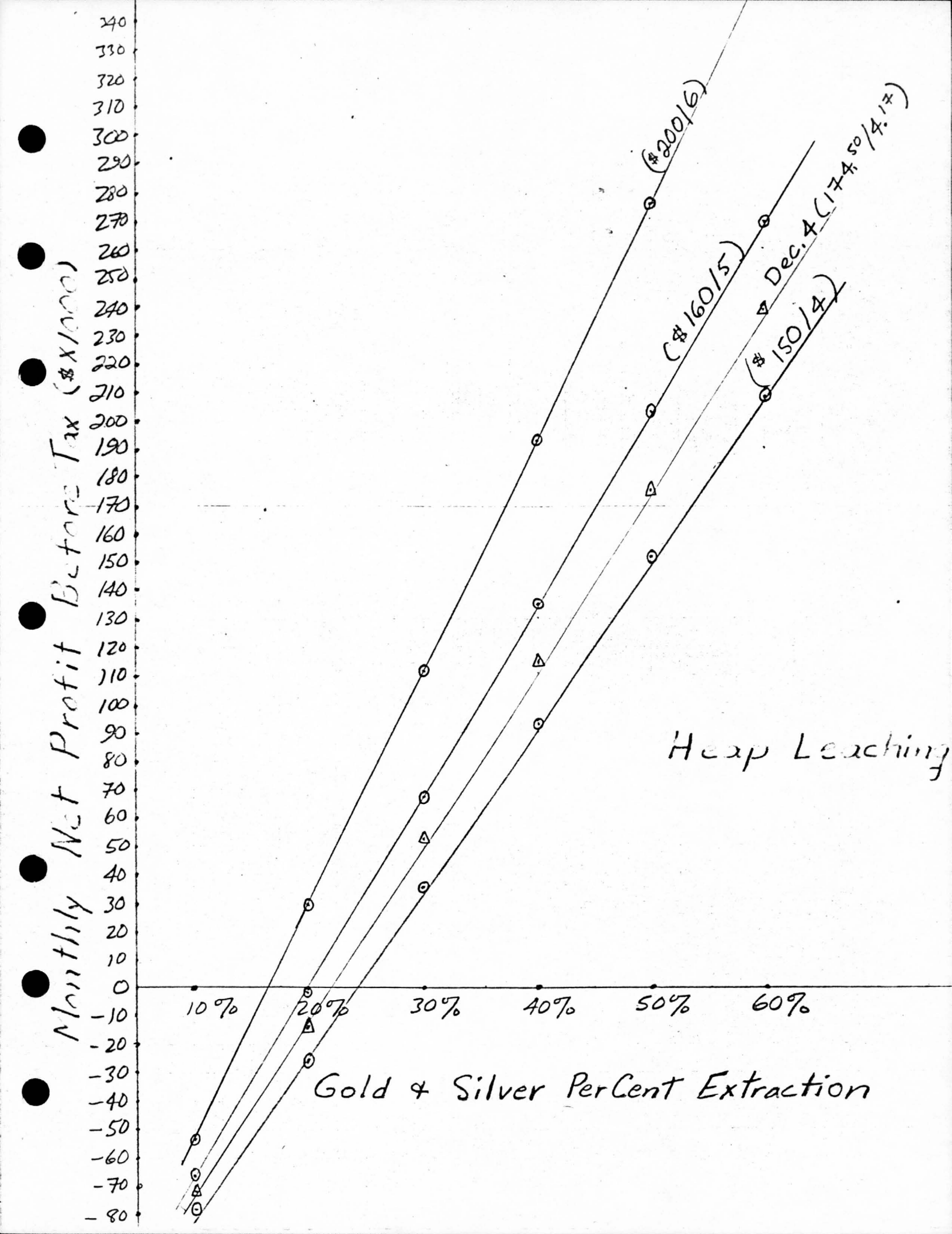
Constants:

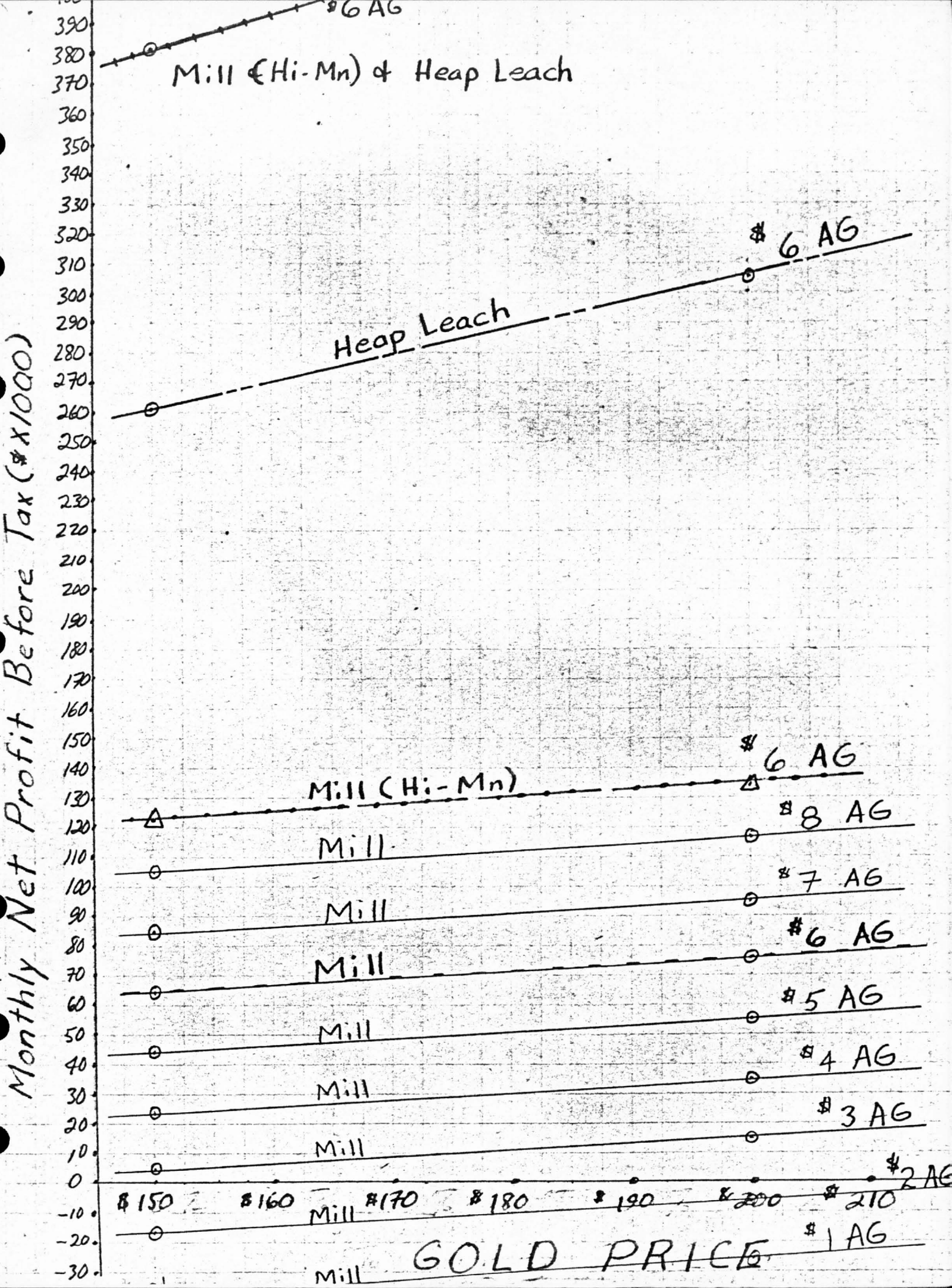
1. Gross Au = 19,999 t. ounces
2. Gross Ag = 1,751,869 T. ounces
3. Total tonnage = 799,940
4. Mill costs are $7.40 per ton
5. Heap leaching costs are $3.00 per ton

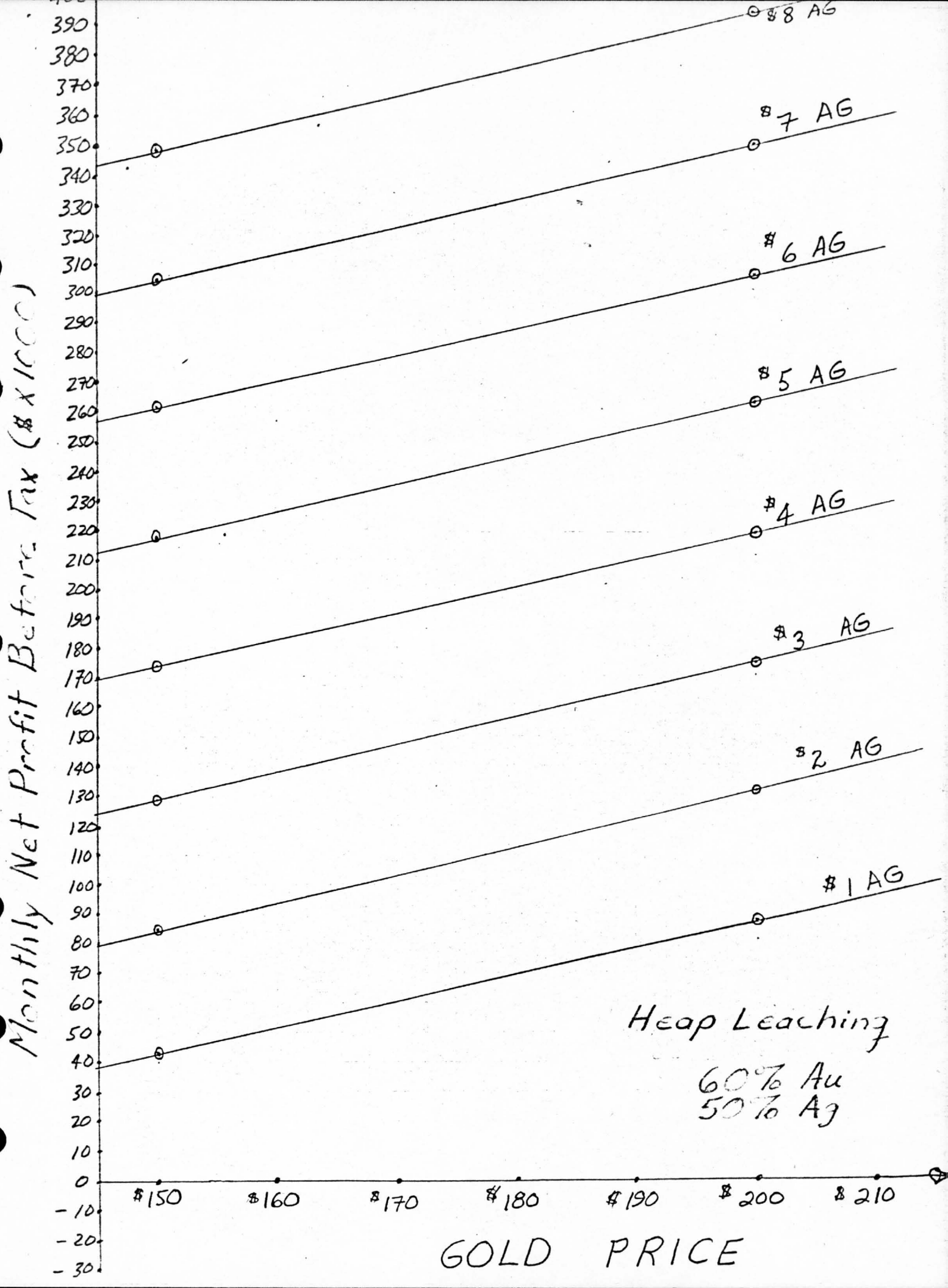
Variables:

1. Precious metal prices (Dec. 5; Au=$178.75, Ag=$4.285
2. Recovery - Mill: assumed 85% Au and 75% Ag
3. Recovery - Heap leach: assumed 60% Au and 50% Ag
4. Heap leaching rate: assumed 1500 tons-per-day

	Heap Leaching & Milling		Milling Only
	Heap Leach	Mill High-Manganese	Mill All Ore
Tons Processed	567,631	210,009	799,940
Extraction Rate	45,000 t.p.m.	12,500 t.p.m.	12,500 t.p.m.
Total Ext. Time	12.6 months	16.8 months	64 months
Recoverable Au	11,239	4,463	16,999
Recoverable Ag	550,602	505,439	1,313,902
Gross Sales	$4,368,301	$2,963,567	$8,668,641
Production Costs	1,702,893	1,554,067	5,919,556
Net Profit B. Tax	2,665,408	1,409,500	2,749,085
Av. Monthly NPBT	211,540	83,899	42,954
Depletion	$609,378	$413,417	$1,209,275


Monthly Net Profit Before Tax ($X1000)
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
10%
20%
30%
40%
50%
60%
Gold & Silver PerCent Extraction
($200/6)
($160/5)
Dec. 4 (174.50/4.17)
($150/4)
Heap Leaching


Monthly Net Profit Before Tax ($X1000)
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
$6 AG
Mill (Hi-Mn) & Heap Leach
$6 AG
Heap Leach
$6 AG
Mill (Hi-Mn)
$8 AG
Mill
$7 AG
Mill
$6 AG
Mill
$5 AG
Mill
$4 AG
Mill
$3 AG
Mill
$2 AG
Mill
$1 AG
Mill
$150
$160
$170
$180
$190
$200
$210
GOLD PRICE


Monthly Net Profit Before Tax ($ X 1000)
390
380
370
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330
320
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300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
$8 AG
$7 AG
$6 AG
$5 AG
$4 AG
$3 AG
$2 AG
$1 AG
Heap Leaching
60% Au
50% Ag
$150
$160
$170
$180
$190
$200
$210
GOLD PRICE

SIERRA METALS

R. F. HEWLETT
President

4741 EAST SUNRISE DRIVE
SKYLINE BEL AIRE PLAZA
TUCSON, ARIZONA 85718
602/299-9736

SUMMARY OF TOMBSTONE HEAP LEACHING TESTS

Dump	Gold, T.oz. per ton			Silver, t.oz. per ton		
	1st Day	3rd	6th	1st Day	3rd	6th
Tranquility	.0133	.0190	.0200	.287	.37	.37
Empire	.0110	.0160	.0167	.193	.27	.27
Toughnut	.0056	.007	.007	.195	.24	.25
Contention #1	.0192	.024	.0244	.40	.54	.55
Little Joe	.0053	.007	.0077	.282	.44	.44
West Side	.0100	.0139	.0154	.453	.57	.57
Grand Central	.00882	.0103	.0103	.448	.58	.60
Lucky Cuss	.01422	.0182	.0182	.383	.55	.56
Emerald	.004	.0046	.0046	.40	.47	.47
Contention #2	.0170	.028	.0295	.764	1.08	1.14

SIX DAY RECOVERY DATA

Dump	Au	Ag	Gross Value ($185/4.50)	NPBT
Tranquility	.0200	.37	$ 5.37	$ 106,650
Empire	.0167	.27	4.30	58,500
Toughnut	.007	.25	2.43	--
Contention #1	.0244	.55	6.99	598,500
Little Joe	.0077	.44	3.40	--
West Side	.0154	.57	5.42	72,600
Grand Central	.0103	.60	4.61	80,500
Lucky Cuss	.0182	.56	5.89	158,950
Emerald	.0046	.47	2.97	--
Contention #2	.0295	1.14	10.59	151,800
				$1,227,500

NOTE: 395,000 tons at an average of $3.11 net profit per ton (not leaching Toughnut, Little Joe & Emerald)

HEAP LEACHING VS. MILLING

Dump	Mill Recvry. (Au/Ag)	H.L. Recovery Troy Ounces Au	H.L. Recovery Troy Ounces Ag	Mill Recovery Troy Ounces Au	Mill Recovery Troy Ounces Ag	Tons
Tranquility	75/75	900	16,650	1,654	53,663	45,000
Empire	75/75	752	12,150	1,316	47,925	45,000
Contention # 1	75/75	3,660	82,500	4,725	163,125	150,000
West Side	81/75	462	17,100	462	36,450	30,000
Grand Central	75/75	515	30,000	1,125	54,000	50,000
Lucky Cuss	75/60	1,001	30,800	1,609	110,550	55,000

Dump	Heap Leaching Gross Value ($185/4.5) Au	Ag	Total	Prod. Cost (3)	Net Profit Before Tax
Tranquility	$166,500	$ 74,925	$ 241,425	$135,000	$106,425
Empire	139,120	54,675	193,795	135,000	58,795
Contention # 1	677,100	371,250	1,048,350	450,000	598,350
West Side	85,470	76,950	162,420	90,000	72,420
Grand Central	95,275	135,000	230,275	150,000	80,275
Lucky Cuss	185,185	138,600	323,785	165,000	158,785

Dump	Milling Gross Value ($185/4.5) Au	Ag	Total	Prod. Cost (7.5)	Net Profit Before Tax
Tranquility	$305,990	$241,484	$ 547,474	$ 337,500	$209,974
Empire	243,460	215,663	459,123	337,500	121,623
Contention # 1	874,125	734,063	1,608,188	1,125,000	483,188
West Side	85,470	164,025	249,495	225,000	24,495
Grand Central	208,125	243,000	451,125	375,000	76,125
Lucky Cuss	297,665	497,475	795,140	412,500	382,640

Dump	Net Profit Before Tax		Net Profit Before Tax Monthly	
	H.L.	Milling	H.L.	Milling
Tranquility	$ 106,425	$ 209,974	$106,425	$58,326
Empire	58,795	121,623	58,795	33,784
Contention # 1	598,350	483,188	179,685	40,266
West Side	72,420	24,495	108,090	10,206
Grand Central	80,275	76,125	72,320	19,031
Lucky Cuss	158,785	382,640	130,152	86,964
	$1,075,050	$1,298,045		

From the above, perhaps an economic criteria for the heap leach vs. mill decision might be:

2. Monthly profit rate
1. Net profit difference

This could be shown as:

Dump	Net Profit Difference		
	Total	Ratio $\frac{(\text{Milling})}{(\text{H.L.})}$	Monthly $\frac{(\text{H.L.})}{(\text{Milling})}$
Tranquility	$103,549 (M)	1.97	1.82
Empire	62,828 (M)	2.07	1.74
Contention # 1	115,162 (H.L.)	0.81	4.46
West Side	47,925 (H.L.)	0.34	10.59
Grand Central	4,150 (H.L.)	0.95	3.80
Lucky Cuss	223,855 (M)	2.41	1.50

Therefore, from the net profit difference, the following are obvious:

1. Heap leach; Contention #1, West Side, and Grand Central

From the net profit ratio~~s~~, the following are shown:

1. Two clusters of values, obvious heap leach (below unity) and about twice the net profit by milling

The monthly net profit ratio (H.L./Milling) shows:

1. A trade-off on the monthly cash flow and net profit difference on the Tranquility, Empire and Lucky Cuss

A present worth analysis of heap leaching the six economic dumps (375,000 tons) follows:

Month	PW (12%)	Income		Discounted Income	
		H.L.	Mill	Heap Leach	Mill
3	.974	$ 387,407	$ 148,500	$ 377,334	$ 144,639
6	.947	387,407	148,500	366,874	140,630
9	.920	300,886	148,500	276,815	136,620
12	.893	--	148,500	--	132,611
15	.869	--	148,500	--	129,047
18	.845	--	148,500	--	125,483
21	.821	--	148,500	--	121,919
24	.797	--	148,500	--	118,355
27	.776	--	148,500	--	115,236
30	.755	--	69,300	--	52,322
		$1,075,700	$1,405,800	$1,021,023	$1,216,862

Therefore, the discounted income is very nearly the same, without considering the differential in capital investment.

DUMP SAMPLING COMPARISONS

Dump Name		Austral Oil Au	Austral Oil Ag	Duval Au	Duval Ag	Sierra Au	Sierra Ag
Empire	us	-	-	-	-	.039	1.42
	s	.080	1.90	.085	1.39	.044	1.58
Tranquility	us	.031	1.42	-	-	.049	1.59
	s	-	-	.082	1.50	.070	2.10
Contention	us	.013	.87	-	-	.016	.90
	s	-	-	.058	1.02	.042	1.45
Little Joe (Grand Central)	us	.010	.60	-	-		
	s	-	-	.051	2.23		
Sulphuret	us	.022	.66	.030	.80		
	s	-	-	-	-		
Silver Thread	us	.025	1.33	-	-		
	s	-	-	.030	2.22		
Lucky Cuss	us	.040	2.98			.039	2.91
	s	-	-			.065	5.01
Toughnut	us	.009	.54			.013	1.52
	s	-	-			.027	2.82
Bonanza		-	6.00			-	5.74
State of Maine		-	4.50			-	3.90
Soltice		.004	2.80			-	3.4
N. Bonanza		.003	1.84			-	4.4
Joseph		-	1.02			-	1.30
Br. Jonathan		-	1.94			-	3.0

NOTE: us = unscreened
s = screened

New Pueblo CONSTRUCTORS Inc.
P. O. BOX 27566
TUCSON, ARIZONA 85726
4115 EAST ILLINOIS STREET — PHONE 748-8000
GENERAL CONTRACTORS AND HEAVY ENGINEERING

KARL G. RONSTADT
PRESIDENT

February 27, 1979

Mr. James Briscoe
S.E.A. Hydromet
4500 East Speedway Blvd.
Tucson, Arizona 85712

Dear Jim:

Confirming the conversation Dick Yaeger, you and I had yesterday I am enclosing copies of estimates for your precious metals project at Tombstone.

To summarize: Estimated costs for varying quantities with a Commander III crusher (16 X 48 jaw, 6' X 20' triple deck screen, triple 30" rolls, 700 hp engine and necessary support equipment), product crushed to 1/2" minus and stockpiled by stacking conveyor only. Excluded are facilities for blending in chemicals or additives

Minimum	150/Ton/Hour	200/Tons/Hour
30,000 Tons	$4.96/Ton	$4.39/Ton
100,000 Tons	3.45/Ton	2.91/Ton
1,000,000 Tons	2.70/Ton	2.14/Ton

Included in the preceding cost is amoritization of the crushing plant and associated conveyors to a maximum of $300,000, an allowance for an increase of 7% in wages over current wage schedules and one month's standby costs on crushing equipment of approximately $15,000.

As an alternative (on behalf of commencing the project and creating current cash flow for minimum expenditure) we have provided a second estimate which includes crushing approximately 30,000 tons to a maximum of 1 1/4". This would be done by a combination of a jaw crusher and an 855 Cedarapids Commander crusher. This equipment would be moved in sometime after March 15, crushing for approximately two weeks, stockpiling 30,000 tons by stacking conveyor and thereupon be removed. It is anticipated this 30,000 tons would be of the highest grade ore available and thereby accelerate cash flow on the project. The remaining course rock above 1/2" could be crushed to a finer dimension (1/2") at a later date. The estimated cost per ton for 30,000 tons would be $2.44/ton or $73,260.00.

Payment for costs incurred would be due 30 days after invoicing. These costs would include all direct costs plus 11% overhead and administration as contained and accounted for in New Pueblo's standard job cost accounting system. Method of defining costs would be in accordance with attached "Schedule of Project Costs".

We propose to take no profit on the project until such time as the cash flow of the project exceeds expenditures and necessary reserves at which time we would receive 10% of the net profit on the project as our share of the profits. Thus we are hereby offering to manage the costs of processing and stockpiling for minimum cost and overhead and participating in the net results as a 10% partner entitled to 10% of the net revenues or benefits. All expenditures concerning the processing and crushing would be subject to review by management of the project and accounting by both parties would be subject to audit as appropriate.

Your acceptance of this proposal by signature below and return of one copy will constitute agreement.

Very truly yours,

NEW PUEBLO CONSTRUCTORS, INC.

Karl G. Ronstadt, President

KGR/kb

Attachments: Two Cost Estimates (copies)
NPC Schedule of Project Costs

ACCEPTED BY:

_____

Date: _____

NEW PUEBLO CONSTRUCTORS, INC.
SCHEDULE OF PROJECT COSTS

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
1. HOME OFFICE COSTS		
A. Executive Salaries & Expenses		X
B. Engineering		
1. Chief Engineer		X
2. Project Engineer	X	
3. Design Engineer	X	
4. Detail Draftsman	X	
5. Material Take-Off	X	
6. Estimating Engineer	X	
7. Specifications Engineer	X	
8. Critical Path Scheduling	X	
9. Engineering Clerk	X	
10. Secretarial Service	X	
11. O.A.B., Social Security and Other Payroll Tax	X	
12. Compensation Insurance, Public Liability and Similar Insurance	X	
13. Payroll and Accounting Expense		X
14. Sick Leave and Absence for Cause		X
15. Standby Salaries		X
16. Pensions		X
17. Proportional Cost of Light, Heat, Rent, etc.		X
18. General Supplies and Equipment		X
19. Personnel Procurement		X
20. Actual Cost of Copy Work	X	
21. Computer Service	X	
22. Overtime As Necessary		
22.1 Straight time portion of cost	X	
22.2 Premium portion of cost	X	
C. Project Management		
1. Project Manager	X	
2. Project Engineers	X	
3. Cost Engineers	X	
4. Stenographic and Clerical	X	
5. Expediters & Purchasing Clerk	X	
D. Central Accounting		
1. Chief Accountant and Staff		X
2. Field Auditor		X

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
1. HOME OFFICE COSTS - cont'd		
E. Labor Relations Personnel		X
F. Construction Manager and Staff		X
G. Chief Purchasing Agent		X
H. General Office Expenses		
1. Traveling Expenses of above employees when on trips authorized by you	X	
2. Long Distance Telephone, Telegraph and Teletype	X	
3. Local Telephone Service		X
4. Rental on Business Machines		X
5. Group Insurance, Hospitalization		X
6. Parcel Post and Express	X	
7. Postage	X	
8. Depreciation, Repairs & Maintenance		X
9. Rent, Light, Heat, Taxes and Insurance		X
10. Office Supplies and Stationery		X
11. Forms required specially for a particular Customer	X	
12. Miscellaneous Items, such as Want Ads, Subscriptions, Dues, Catalogs, Bulletins		X
13. For monthly field service which includes project ledgers, cost report work sheets, cost reports, field payroll earnings records, quarterly reports, workmens compensation for field personnel.		X
2. MATERIALS, SUBCONTRACTS, AND CONSTRUCTION SUPPLIES COSTS		
A. Actual cost of all material and equipment, including transportation and unloading of same, whether purchased by you or by ourselves. All discounts and commissions are passed on to the Customer.	X	
B. Actual Manufacturing cost of any Equipment made in our shops. Equipment can be furnished at fixed prices.	X	

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
MATERIALS, SUBCONTRACTS, AND CONSTRUCTION SUPPLIES COSTS - cont'd		
C. All Subcontracts	X	
D. All expendable materials and construction supplies, also water & electricity	X	
3. FIELD LABOR AND RELATED COSTS		
A. Salaries and Wages		
1. Field Superintendent of Construction	X	
2. Assistant Superintendent	X	
3. General Foreman	X	
4. Resident Engineer	X	
5. Chief Surveyor	X	
6. Instrument Men, Stakers & Rodmen	X	
7. Field Accountant and Staff	X	
8. Cost Analysis Engineer	X	
9. Timekeepers	X	
10. Field Purchasing Agent	X	
11. Warehousemen and Helpers	X	
12. Safety Engineer, Doctor & Nurses	X	
13. Watchmen and Guards	X	
14. Other necessary Non-Manual Field Employees	X	
15. Overtime pay for 3-A (1 to 14) above, in accordance with Established Policy and with your prior approval	X	
15.1 When Overtime is Worked, the overtime premium payroll will be a job cost.		
16. Vacation and Holiday allowances, in accordance with NPC policy	X	
17. Sick leave for monthly salary employees		X
B. Travel and living expense and subsistence for personnel 3-A (1 to 14) above, in accordance with NPC policy	X	
Social Security, Unemployment Insurance and Payroll Taxes applicable to Employees, 3-A (1 to 15) above.	X	
D. All Job Site Craft and common labor salaries, wages and fringe benefits as required by working rules of Unions having jurisdiction, including travel and premium pay allowances for field manual employees.	X	

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
FIELD LABOR AND RELATED COSTS - cont'd		
D(a) When overtime is worked, the premium overtime payroll will be a job cost with no addition for Contractors burden or fee.		
(1) Labor for tie in of subcontract installations	X	
(1.1) Material for tie in of subcontract installations	X	
(2) Labor to install changes after start-up	X	
(2.1) Material needed to install changes after start-up	X	
E. Social Security, Unemployment Insurance and Payroll Taxes applicable to employees in 3-D.	X	
F. Workmen's Compensation; Liability, Property Damage, Builders Risk and other insurance as required.	X	
G. Cost of labor recruitment, testing and transportation to the Job Site.	X	
H. Cost of labor negotiations, specifically for this work as required.	X	
I. Cost of Engineers, Technicians, or Manufacturer's Specialists for installation and start-up.	X	
4. CONSTRUCTION EQUIPMENT AND TOOL COST		
A. Transportation and handling costs to move tools and equipment to and from the job.	X	
B. Purchase of major construction equipment.	X	
C. Rental of major construction equipment from others, at cost (outside rented equipment).	X	
D. Rental and transportation of any construction equipment, whether furnished by contractor or others. Rental rates for contractor owned equipment, if available, will be negotiated.	X	

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
4. CONSTRUCTION EQUIPMENT AND TOOL COST - cont'd		
D(a) Normally NPC equipment "Use" rate will be charged. This rate includes all costs of ownership, and operation except operator labor. These rates are fueled & maintained, and are based on A.E.D. Rates. 50% of this rate will be charged for stand-by time. No charge will be made if equipment is stored or inoperative.		
E. Small Tools and Rigging	X	
F. Maintenance of outside rented equipment and tools, including renovating at end of job.	X	
G. Gas, Oil and other maintenance supplies on outside rented equipment only.	X	
5. MISCELLANEOUS JOB COSTS		
A. Temporary Construction Facilities	X	
B. Field Office, Furniture, Office Equipment	X	
C. Building Permits and Licenses	X	
D. Field Telephone & Telegraph	X	
E. Premium of Compensation Insurance, Public Liability and Property Damage, Automobile Public Liability and Property Damage, and any other insurance required for Field Payroll or Plant, job incurred only.	X	
F. Losses or Expenses not compensated by Insurance.	X	
G. Rental cars at cost.	X	
H. Sales, Use and Privilege Taxes (if any).	X	
I. All other direct cash outlays for job costs not specifically excluded.	X	
J. Outside consultants.	X	

Description	I Items Reimbursable At Cost, Including Direct Costs on Salaries & Wages	II Non-reimbursable Items Covered By Administrative & Overhead Charges
MISCELLANEOUS JOB COSTS - cont'd		
K. Inspection in Suppliers Shop or in Field. Includes travel time and travel and living expense.	X	
L. Cost of legal fees and expenses caused by Force Majeure.	X	
M. Cost of Performance Bond (if required).	X	

METALLURGY

METALLURGICAL TESTING

Tombstone problem ore types classified by leaching characteristics are as follows:

1. High-iron and clay; eastern portion of District from the Empire to Grand Central along the Contention Dike.

2. Sulfide ores

3. Argentojarosite

4. Manganese carbonate-oxide minerals

5. Silicious interstitial minerals

6. Carbonaceous ores

7. Oxidized sulfide ores.

These ore types cause serious precious metal recovery problems when using cyanide.

In addition to the chemical-mineralogical problems caused by these ore types, physical problems that cause poor recovery when '71 Minerals leached the heap are:

1. Clays and fines caused blinding and would not percolate.

2. Coarse ores could not leach into the rock; values locked inside the rock were not exposed to leaching.

Screen analysis of various coarse and fine fractions of the ore from all of the dumps appears in the ore reserve section. Notice that there are good values in the coarse; it is economical to crush and re-leach; "IPS" will yield high recovery of the crushed ore.

Cyanide

Ore from the Contention area(no manganese) was sampled and one split was digested with acid(aqua regia) and an equal split was digested with cyanide. Results from 24 tests show that cyanide recovered only 35% of the precious metal values(see the following table). Careful study of these results show that the acid digest recovered about 6½ fold more gold than the cyanide digest. However, the cyanide digest recovered 1¼ fold more silver than the acid digest. This is due to:

A. Cyanide does not break down the encapsulating carbonates that prevent the gold from complete leaching.

B. Acid breaks down silicious gold ores that cyanide does not chemically attack.

C. Acid breaks down gold-limonite-clay complexes that are only slightly effected by cyanide.

D. Silver nitrate formed with aqua regia is partially precipitated by the chlorine ion(from the hydrochloric acid);silver cyanide complex is more stable than the gold chloride complex.

Manganiferous ores were leached with cyanide and aqua regia. Emerald ores were the very fine ore, and showed that cyanide leached only 11% of the gold leached by the acid.

Sodium thiosulfate

Sodium thiosulfate is an effective solvent for silver. Following are the results:

Concentration (gr/l)	Silver Leached (t.oz./ton ore)	Troy Oz. Ag Gr. Hypo per liter
20	1.33	.067
10	1.23	.123
5	1.00	.200
2½	.73	.292
1¼	.48	.384
.625	.32	.512
.3125	.22	.704

TOMBSTONE

Solvent Comparison

Sample Location	ACID Aqua Regia Gold	ACID Aqua Regia Silver	BASE Cyanide Gold	BASE Cyanide Silver
	Precious Metal Recovery (t.oz./ton ore)			
1-Heap/Dump	.105	.24	.003	.15
2-No. Ramp(N)	.075	.30	.009	.27
3-No. Ramp(S)	.090	.42	.030	.45
4-Dump	.075	1.14	.009	1.56
5-Dump,small	.090	1.02	.024	1.65
6-Dump,larger	.180	.69	.015	1.08
7-Dump, LN.	.150	1.05	.015	3.75
8-Large Dump	.150	.30	.009	.36
9-Dump-south	.150	.30	.012	.06
10-N. end pad	.075	.21	.009	.24
11-Y-gate	.267	.54	.015	.27
12-PT;west	.081	1.05	.030	1.98
13-PT;W/M	.048	2.67	.015	1.02
14-PT;M	.120	1.68	.015	2.76
15-PT;E	.075	1.02	.027	1.17
16-PT;Rojo	.075	.99	.003	.24
17-L.Cont(S)	.207	1.95	.057	3.48
18-L.Cont(N)	.120	.93	.012	.69
19-P.Shaft(E)	.120	.24	.018	.27
20-P.Shaft(W)	.072	.27	.027	.48
Flora Morrison	.264	.69	.006	.09
Tailings	.096	.84	.030	1.20
Cont.Dump(W)	.120	1.74	.024	1.26
Cont.Dump(E)	.102	1.08	.039	2.28
	.121	.89	.018	1.12

This is very similar results to that produced previously with Tombstone ores(see Metallrgical Testing Section).

Also, notice the similar leaching rates and recoveries of Hypo and cyanide.

It was also shown that a weak Hypo solution and cyanide in combination leached about the same amount of silver, but Hypo and cyanide leached 150% more gold than cyanide.

Using .5 grams/liter Hypo leach solution, we have obtained for many days a .25 t.oz. silver preg, which conforms with our leaching tests.

Halide-Sodium Hypochlorite System

Halide-sodium hypochlorite systems have been proven an effective solvent for Tombstone ores. Also, a halide-sodium hypochlorite system is a very effective pre-treatment prior to cyanidation.

For all Tombstone ores, pre-treatment with NaCl-NaOCl increases the gold and silver recovery by over 200%.

The following graph presents silver solubility test results for Tombstone silver ore in a 3% NaOCl solution with various amounts of salt(chloride ion). It is obvious that salt is important for our pretreatment.

Refractory Silver Minerals

Silver Sulfide Ores;

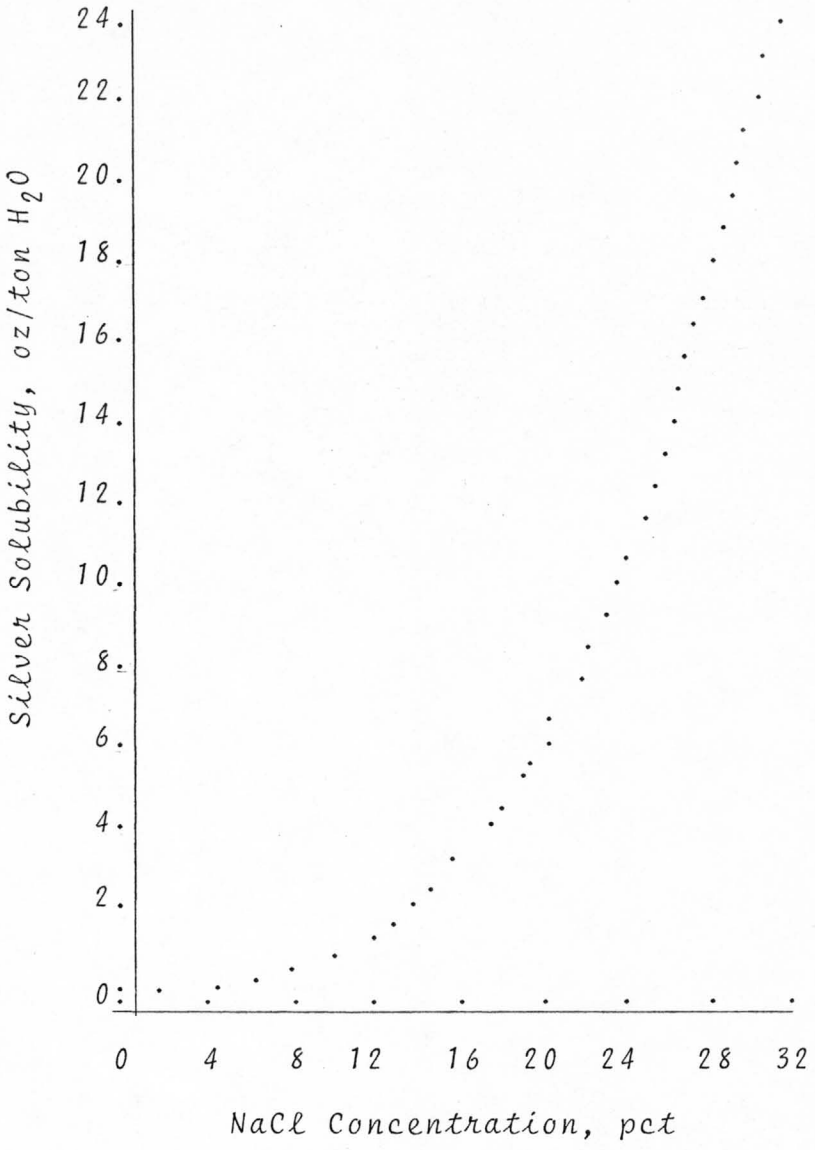
Silver sulfide minerals can be converted to soluble silver chlorides by sodium hypochlorite-brine leaching system. Argentite is leached in an oxidizing brine by:

$$Ag_2S + 4OCl^- = 2AgCl + SO_4^{=} + 2Cl^-$$

Silver chloride is soluble in either a cyanide solution as a cyanide complex or in a brine solution containing excess chloride ion as the tetrachloro complex, as:

(1). $AgCl + 2CN^- = Ag(CN)_2^- + Cl^-$

(2). $AgCl + 3Cl^- = AgCl_4^{-3}$



Solubility of silver ores from Tombstone in a 3% NaOCl solution with varying NaCl.

Manganiferous Ores;

There are basically two oxide manganese minerals, as:

Mn Valence	Formula
II	MnO
IV	MnO_2

In order to dissolve the above, the following acids are required:

Mn(IV) ..... Reducing Acid ----- H_2SO_3

Mn(II) ..... Any Acid ----- H_2SO_4

The reaction for such a system can be expressed as follows:

$$MnO_2 + SO_2 + MnSO_4$$

Solid Gas Aquous

$$H_2O + SO_2 + \tfrac{1}{2} O_2 = H_2SO_4$$

Gas Gas Aquous

Also, the oxide iron minerals would be soluble in an acid media:

$$Fe_2O_3 + 6H^+ = 2Fe^{+3} + 3H_2O$$

Manganiferous Ore Testing

Following are tests made with Emerald ore:

Test ID	H_2SO_4 Consumption	Est. Mn	% Silver Recovery	% Gold Recvr.
Em-1	287 #	1%	85%	88%
Em-2	245 #	2%	85	89
Em-3	230 #	1%	80	84
Em-4	306 #	4%	51	65

This resulted in:

Test ID	#H_2SO_4/Oz. Ag	$$H_2SO_4$/Oz. Ag
Em-1	76.74	$0.244
Em-2	48.74	.155
Em-3	82.14	.261
Em-4	222.22	.707
Ave.	113.19	.360

Therefore, the amount of only silver liberated by a ton of sulfuric acid is over $15 per $1 spent for acid. With the gold content, over $20 in precious metals is recovered per $1 spent for H_2SO_4.

PRE-TREATMENT

"Pre-Treatment" has come to mean anything done to an ore before cyanidation. However, it may not be required or desireable to use cyanide as the final gold solvent.

Common "problem ores" at Tombstone are as follows:

A. Ore with precious metal values more uniformly distributed within the competent rock than on fractures (or fracture planes). This is only a problem for heap leaching; crushing can now be done for maximum value liberation and IPS is used to enable excellent perculation during heap leaching.

B. Dump or other ores with clay and fines that inhibit percolation in heap leaching; IPS allows percolation.

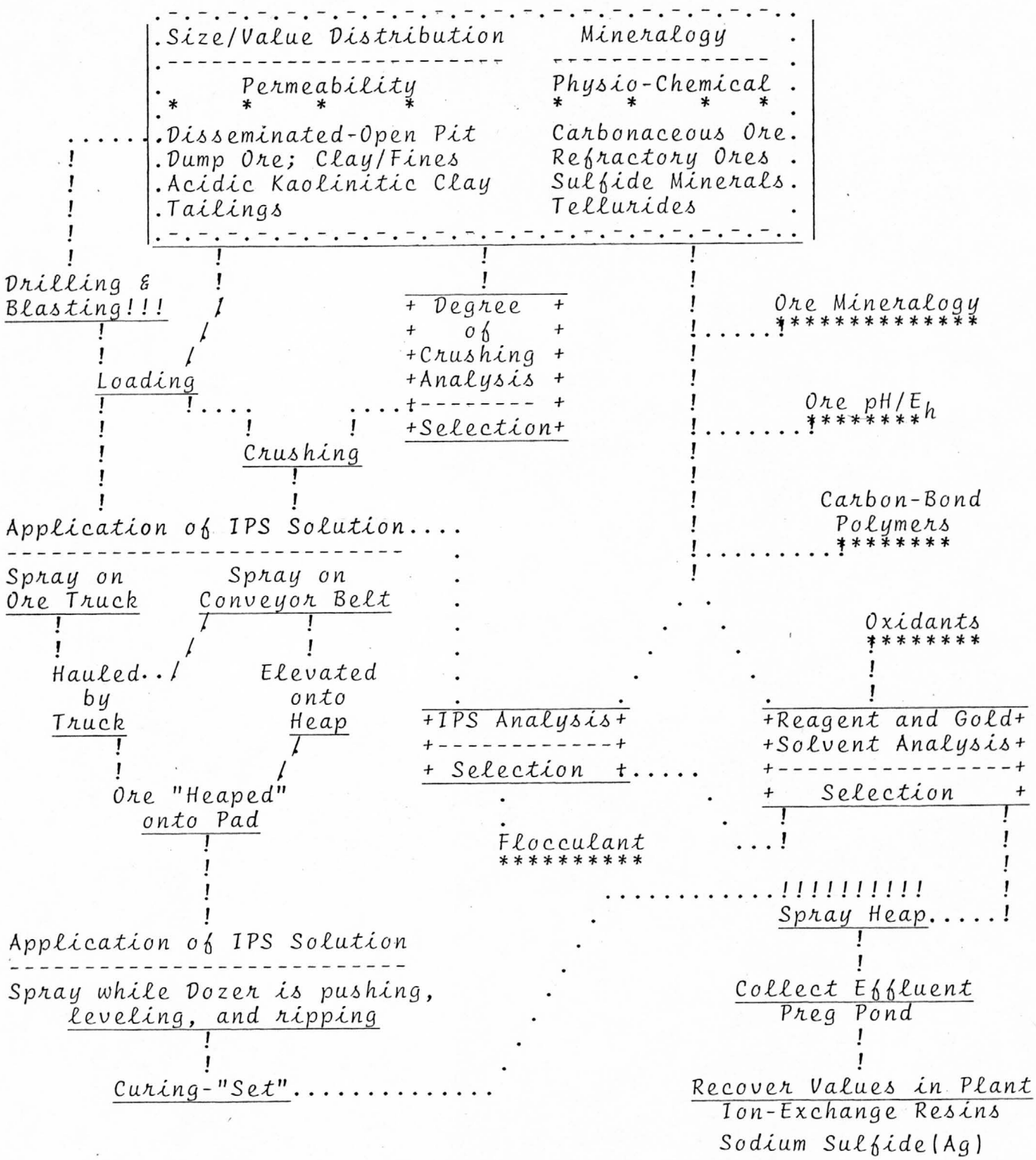
C. Acidic kaolinitic clays (common along the Contention Dike) are real pH problem for using cyanide, as well as the poor percolation in heap leaching problem. IPS solves the percolation problem, while non-cyanide solvents are by far more economic.

D. Montmorillinite clays are common at Tombstone because they form in limestone environments (see Clay Technology section at end of "IPS"/next chapter). These clays cause blinding.

E. The oxygen has been consumed in the heap by copper forming a cuprous cyanide complex. Also, the height of a 100 feet contributes to the depletion of oxygen lower in the heap as solutions percolate in depth.

F. Manganiferous ores have gold and silver "locked" mineralogically.

PRE-TREATMENT
of
Various Problem
Precious Metal Ores
for
HEAP LEACHING



Carbonaceous and Reducing Ores

The organic material in the Tombstone ores creates a problem similar to Tombstone gold and silver ores that are in an oxygen deficent environment in the heap (reducing environment).

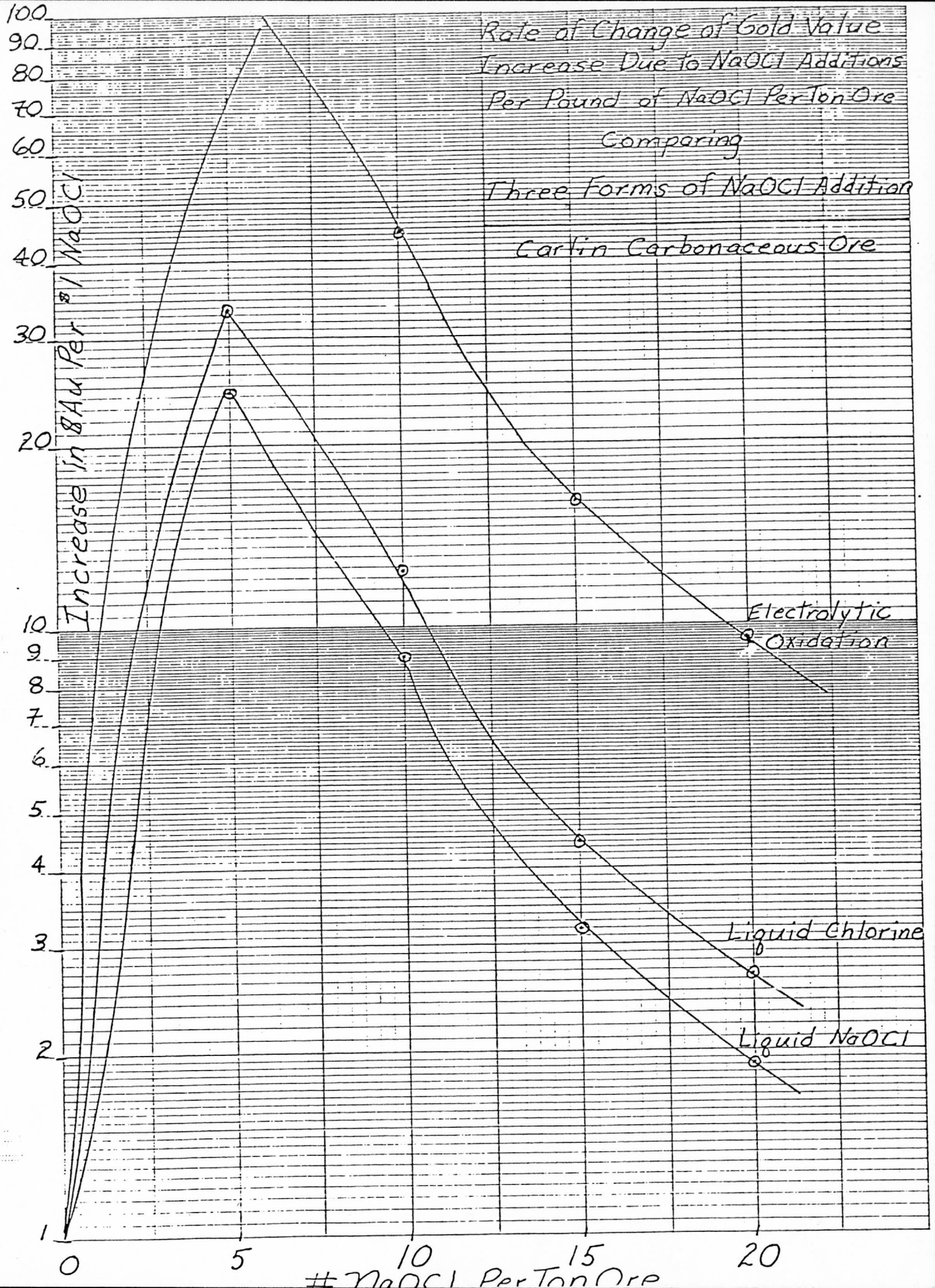
The degradation of organic substances buried in fine-grained sedimentary rocks depends upon the depth of burial and the Geothermal Gradient. This temperature-time relationship is also affected by the exhaustion of available oxygen, lowering the E_h of the sediment. The oxidation reaction takes place faster than the decarboxylation of this organic matter, making oxidation a better choice of pre-treatment than chemical break-down. Total dehydrogenation of organic (carbon bond) substances results in graphite. Other substances produced are fats, carbohydrates, proteins, and amino acids.

The problem basic to the leaching of carbonaceous and reducing ores is that when cyanide is used, the gold-cyanide complex ($Au(CN)_2^-$) is absorbed by the carbon components in the ore. Most tests run on carbonaceous ores show that only about 30% of the gold can be extracted by using a cyanide leach. Because this is on crushed and pulverized ore for mill treatment, that recovery (30%) makes milling uneconomical. Carbonaceous limestones and shales at Tombstone exhibit this phenomeon.

Newmont has applied a technique developed by the U.S. Bureau of Mines at their Carlin gold mine. They use sodium hypochlorite as an oxidant. I have used hypochlorite for this same purpose for the last several years, and it is clearly one pre-treatment reagent that is effective on reducing and other carbonaceous ores. In fact, the use of salt (NaCl) as a source of chlorine was used for gold leaching before the development of cyanide (pre-1900). There are three ways to add hypochlorite to an ore for pre-treatment, which are:

1. Add sodium hypochlorite directly in solution
2. Add liquid chlorine directly
3. Add hypochlorite by in situ generation

The following figure presents the increase in gold value due to the hypochlorite pre-treatment for Carlin carbonaceous ores. Note that in addition to showing the response of the ore to pre-treatment, I have compared the economics of the three methods of pre-treatment using hypochlorite.


Rate of Change of Gold Value
Increase Due to NaOCl Additions
Per Pound of NaOCl Per Ton Ore
Comparing
Three Forms of NaOCl Addition
Carlin Carbonaceous Ore
Increase in $Au Per $1 NaOCl
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0
5
10
15
20
NaOCl Per Ton Ore
Electrolytic Oxidation
Liquid Chlorine
Liquid NaOCl

The application of sodium hypochlorite is sensitive to pH, as is illustrated by the following two figures. Notice that for the Carlin ore, the amount of lime added is as important as the amount of hypochlorite, in fact it can be more important.

The Carlin carbonaceous ore have been analyzed as follows:

Ore Category	Ore Type	Organic Carbon	Au, t.oz./ton
I	Carbonaceous	0.60 %	.40
II	"	.45 %	.19
III	"	.42 %	.33
IV	Oxidized-sl. C	.06 %	.20

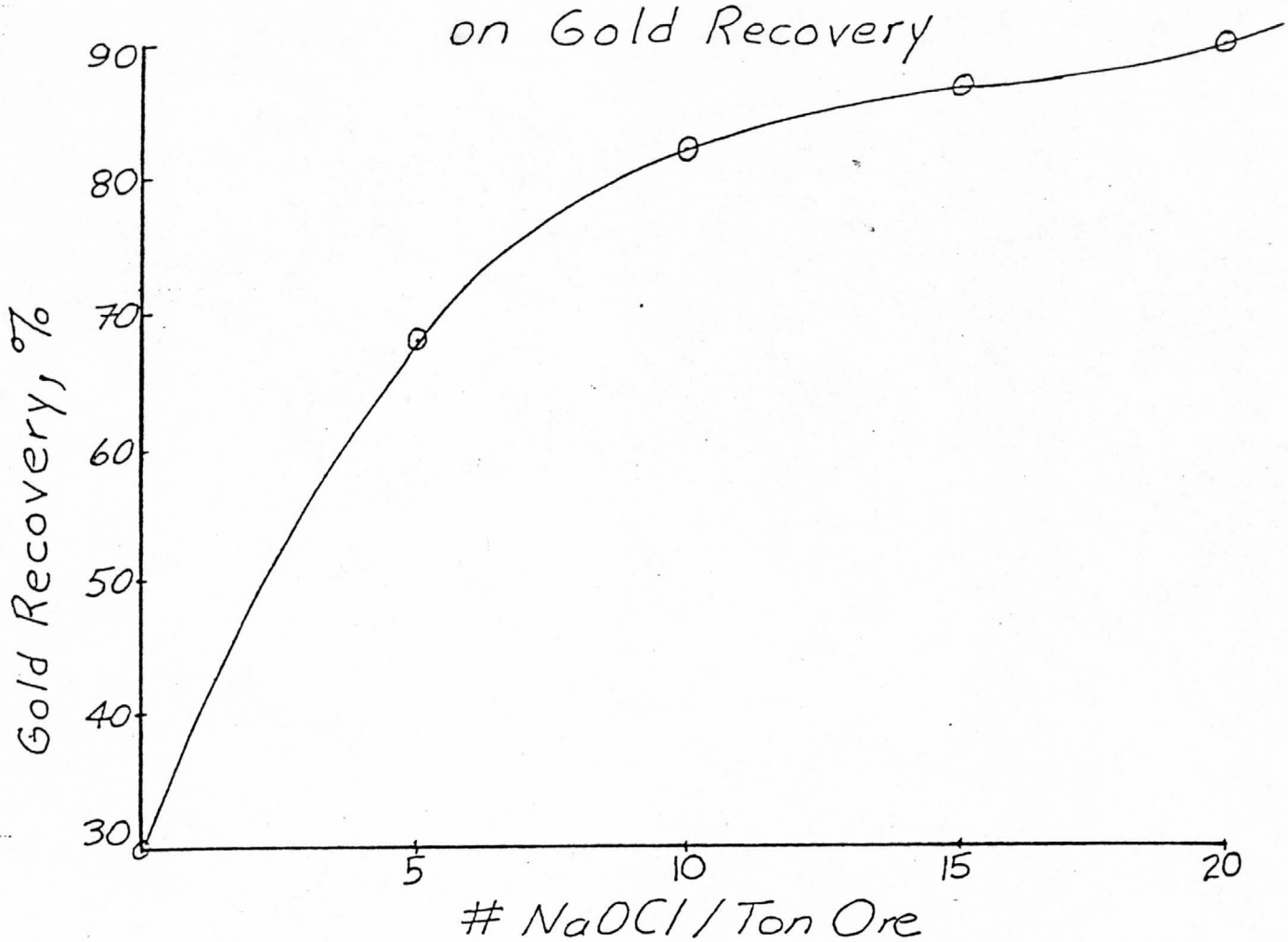
These have all responded differently to hypochlorite, but all with positive results. Testing is the only way to quantify the response of any pre-treatment reagent/solvent.

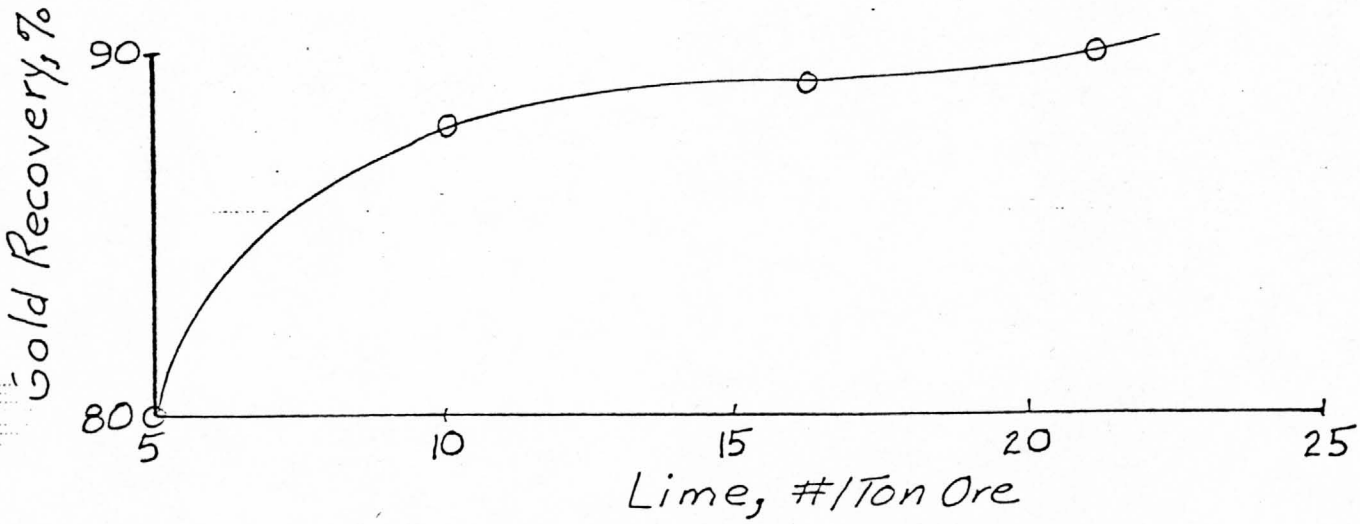
Notice that in the last illustration that the response of two Carlin ore types is presented. It is obvious that the type III would have a better response because hypochlorite is a much stronger oxidant in more acid pH's; under a pH of 7 the oxidation potential of hypochlorite is much greater and chlorine is released which is a solvent for gold. The only restriction for carbonaceous ores is that they usually are in limestones, which consume acid. Notice that the Carlin carbonaceous ore type I has a natural buffered pH at 9; hypochlorite response is stopped at a pH of 9 due to the liberation of hydroxyl ions on fine grinding.

Due to my discussion of hypochlorite, it is obvious that some benefit can be obtained on the Tombstone ores using OCl^- as a pre-treatment reagent. However, testing will quickly quantify the economics of all reagents and solvents that would be used in the pre-treatment of the Tombstone ore, whether for milling or heap leaching.

Carbonaceous Ore

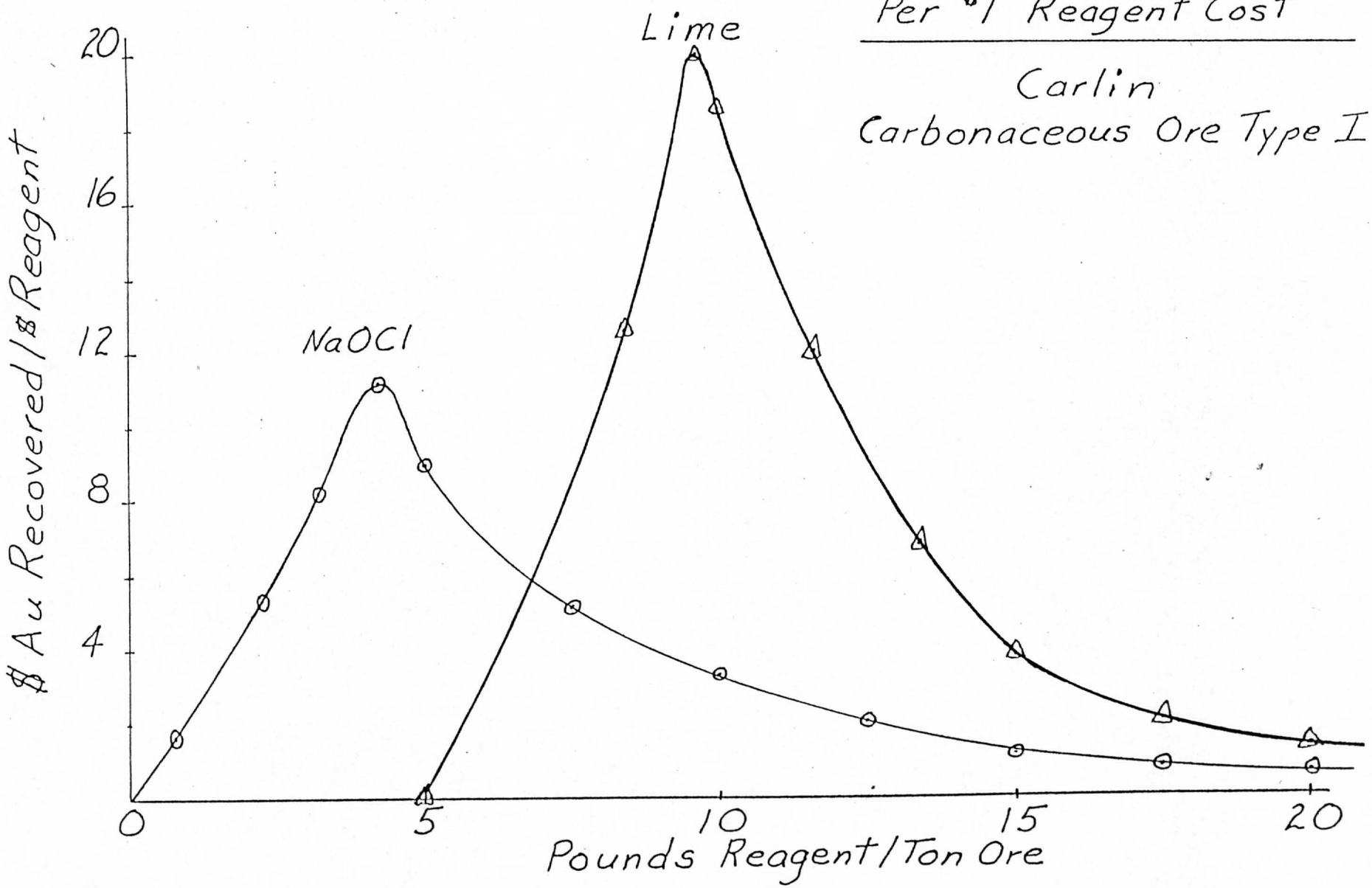
Effect of Quantity of NaOCl & Lime on Gold Recovery

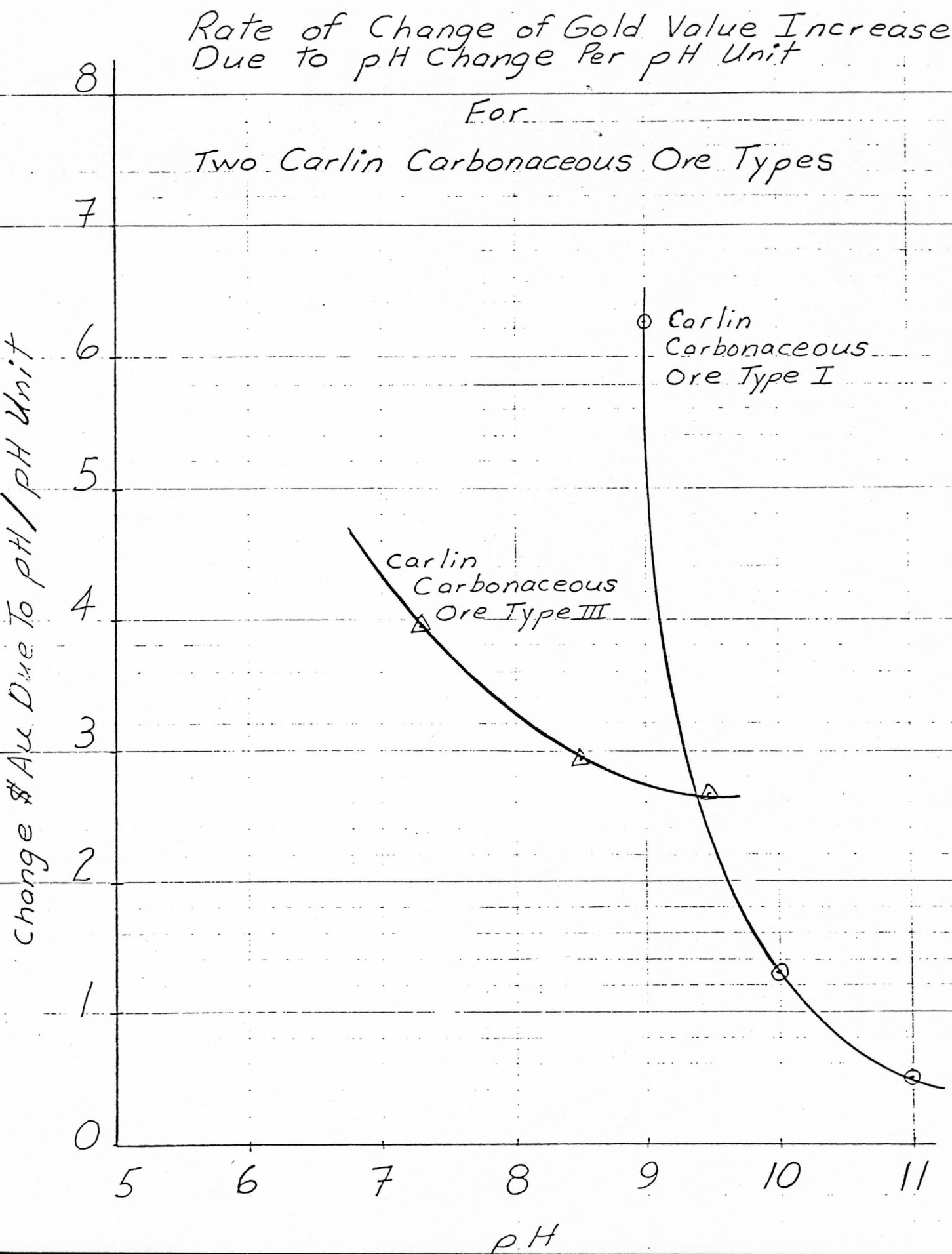




Comparison of Increased Au Value
(Due to Increased Reagent Quantities)
Per $1 Reagent Cost

Carlin
Carbonaceous Ore Type I




Rate of Change of Gold Value Increase
Due to pH Change Per pH Unit
For
Two Carlin Carbonaceous Ore Types
Carlin
Carbonaceous
Ore Type I
Carlin
Carbonaceous
Ore Type III
Change $Au Due To pH / pH Unit
pH
0
1
2
3
4
5
6
7
8
5
6
7
8
9
10
11

R. F. HEWLETT
PHONE (702) 731-1601

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BASIC METALLURGY

Pre-Treatment

A. Oxidized Sulfides

Sulfuric acid is formed when water is circulated over the ore on the heap. The amount of oxidized sulfides present determines the increase in acidity due to the addition of water(circulation). For example, the pH of the "leaching-water-source" could start at 6 and then lower to 5 due to the H_2SO_4 formed in the circulation solution.

An effective utilization of the acid solution as a solvent is by adding salt.

The $H_2SO_4 + NaCl = HCl + Na_2SO_4$

The formation of HCl is useful as follows;

1. There are numerous silver compounds that are soluble in acids and not NaCN

2. The ore then consumes the acid and the pH becomes more basic.

B. Un-Oxidized Sulfides

Acid pre-treatment solvents that dissolve silver sulfides are;

Mineral	Solvent
Argentite	HCl
Acanthite	H_2SO_4
Both of above	NAOCl

SILVER COMPOUNDS SOLUBLE IN ACID SOLUTIONS BUT NOT CYANIDE

Name	Formula
Silver acetylide	Ag_2C_2
" orthoarsenate	Ag_3AsO_4
" orthoarsenite	Ag_3AsO_3
" benzoate	$AgC_7H_5O_2$
" bromate	$AgBrO_3$
" carbonate	Ag_2CO_3
" chlorate	$AgClO_3$
" perchlorate	$AgClO_4$
" ferricyanide	$Ag_3Fe(CN)_6$
" fluride	AgF
" fluosilicate	$Ag_2SiF_6 \cdot 4H_2O$
" fulminate	$Ag_2C_2N_2O_2$
" iodate	$AgIO_3$
" mercury iodide(ic)	$2AgI \cdot HgI_2$
" nitrate	$AgNO_3$
" nitrite	$AgNO_2$
" nitroprusside	$Ag_2Fe(CN)_5NO$
" peroxide	Ag_2O_2
" palmitate	$AgC_{16}H_{31}O_2$
" metaphosphate	$AgPO_3$
" propionate	$AgC_3H_5O_2$
" salicylate	$AgC_7H_5O_3$
" selenide	Ag_2Se
" sulfate	Ag_2SO_4
" (Pyrargyrite)	Ag_3SbS_3
" (Proustite)	Ag_3AsS_3

R. F. HEWLETT
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C. Base Metals

Copper oxide minerals (including sulphates, carbonates, etc.) are soluble in both sulfuric and hydrochloric acids. It is very important not to get copper in the zinc-precipitation system because copper retards silver precipitation (replacement) and the refinery will penalize for copper content.

Lead salts interfer with the zinc precipitation from a cyanide solution.

These will settle during the acid phase, but enough settling time must be allowed.

Solvent Selection

A. Sodium chloride (NaCl)

Use of salt was discussed in pre-treatment. Free chlorine ion is very important for good dissolution of silver and gold. Higher recovery is obtained in the cyanide phase by using weak salt solutions.

B. Sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)

Sodium thiosulfate is a very effective solvent for silver. I have extensively utilized "hypo" on a commercial scale at Tombstone for leaching underground and circulating to the plant at 60 GPM for about 6 months. Hypo does not interfer with cyanide; they can be used together. Hypo can be used in a pH range of 3 to 12. For numerous reasons, Hypo should be used in very weak solutions; its dissolution rate for silver and its decomposition rate. Also, sunlight effects Hypo. However, it can very effectively and economically be utilized.

Following are the results of composite halide silver ores (Tombstone, Reville, Packard, & Candelaria) that have been tested with Hypo.

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C. Sodium hypochloride (NaOCl)

Sodium hypochloride is an effective solvent for oxide minerals as gold and silver. Also, it is a good oxidant and a strong base; in a 14% solution the pH is 12.5. Sodium hypochloride is a good solvent to use in the pre-treatment phase because if it follows the use of salt, the oxidation acts like HNO_3 in changing the valence and gold(as well as silver) dissolves-just like aqua regia.

Utilization of NaOCl as an oxidant and source of free chlorine prior to the cyanide phase is very effective because gold and silver chloride complex is dissolved by the more stable cyanide complex. Also, the addition of oxygen increases the dissolution rate of gold and silver in cyanide; it has been shown that 6 ppm oxygen is necessary for the most efficient dissolution rate. Also, the dissolution rate drops off very rapidly with decreasing amounts of oxygen.

D. Cyanide (NaCN)

Cyanide is the most commonly used gold and silver solvent. Dissolution rates for silver are much slower than for gold, and it was pointed out that oxygen is necessary.

Elsner's fundamental cyanid-silver equations are:

<u>Halides</u> $2Ag + 4NaCN + O + H_2O = 2AgNa(CN)_2 + 2NaOH$

<u>Sulfides</u> (1) $Ag_2S + 5NaCN + O + H_2O = 2NaAg(CN)_2 + NaCNS + 2NaOH$

(2) $Ag_2S + 4NaCN = 2NaAg(CN)_2 + Na_2S$

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Basic silver-cyanide problems and their solution are:

Basic Problem	Solution
Slow dissolution rate	Stronger solutions and good perculation-lower vertical lifts on the heap; adds oxygen. Pre-Treatment with acid solvents. Add oxidants.
Oxygen requirement	Above, plus spray(as rainbird); monitor preg at base of heap-keep at 6 ppm free oxygen.
Sulfates of iron; ppt. silver in heap	Decompose with lime
Sulfide solutions ppt Ag	Add $Pb(C_2H_3O_2)_2$ - allow to settle
Soluble Pb salts interfer with Zn precipitation	Precipitate and settle with acid pH--design large settling ponds
Silver sulfides are hard to dissolve with CN	Pre-treatment with NaCl and NaOCl
Tetrahedrite, sulf-antimonides, and sulf-arsenides are hard to dissolve in CN	Pre-treatment with NaCl, H_2SO_4, $FeCl_3$, and NaOCl
Oxidized Zn & Cu oxides, carbonates, and hydrates and soluble sulfides--- cause high CN consumption	Numerous pre-treatment; basically acid with NaCl and NaOCl

R. F. HEWLETT
PHONE (702) 731-1601

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Economic Analysis

To determine the optimum selection of solvents, various bench-shaker tests should made followed by barrel leach tests. These are as follows:

1. Silver dissolution rate per solvent
2. Optimum solvent concentration.

Suggested initial test increments for each solvent are:

Solvent	Solvent Concentration Increments
Sod. thiosulfate	1/2. 3/4, 1, 2, 5 grams/liter
Sod. chlorite	1, 2, 5, 10, 20 grams/liter
Sod. hypochlorite	5, 10, 20, 50 ml/liter of 14 % soln.
Ferric chloride	1/4, 1/2, 1, 5 grams/liter
Aqua regia	5, 10, 20, 50 ml/liter
Cyanide	1/2, 3/4, 1, 1.5, 2 grams/liter
HCl	5, 10, 20 ml/liter
HNO_3	5, 10, 20 ml/liter

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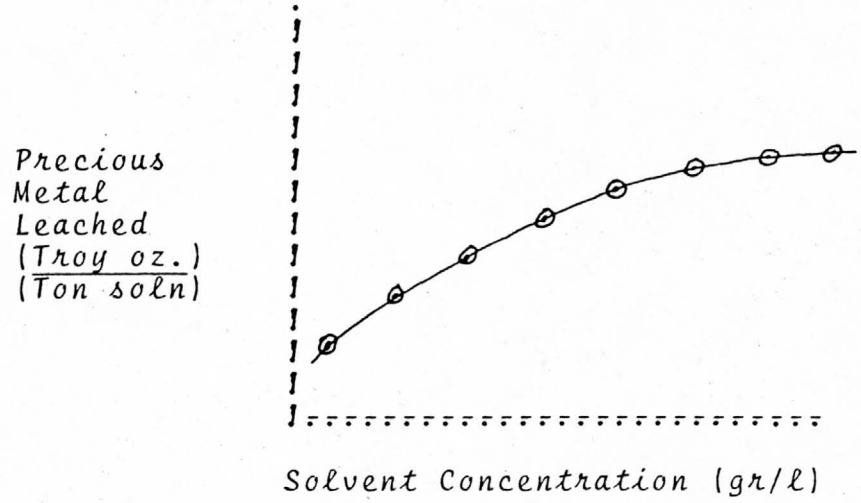
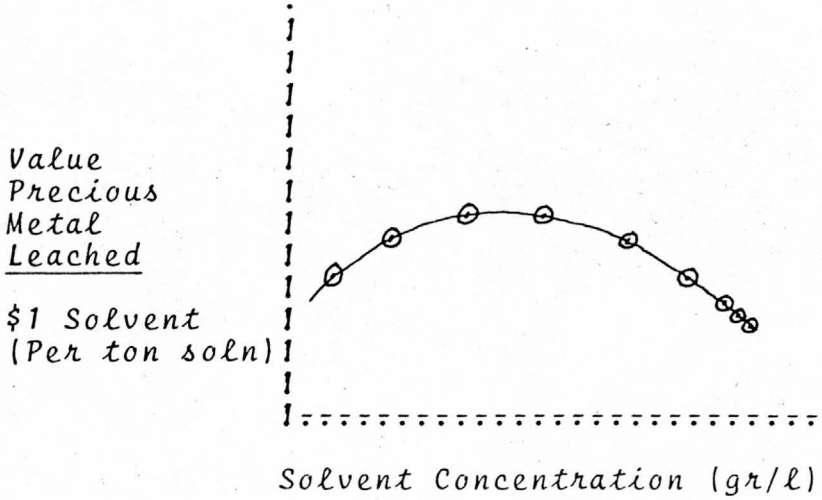
SOLVENT ECONOMIC ANALYSIS





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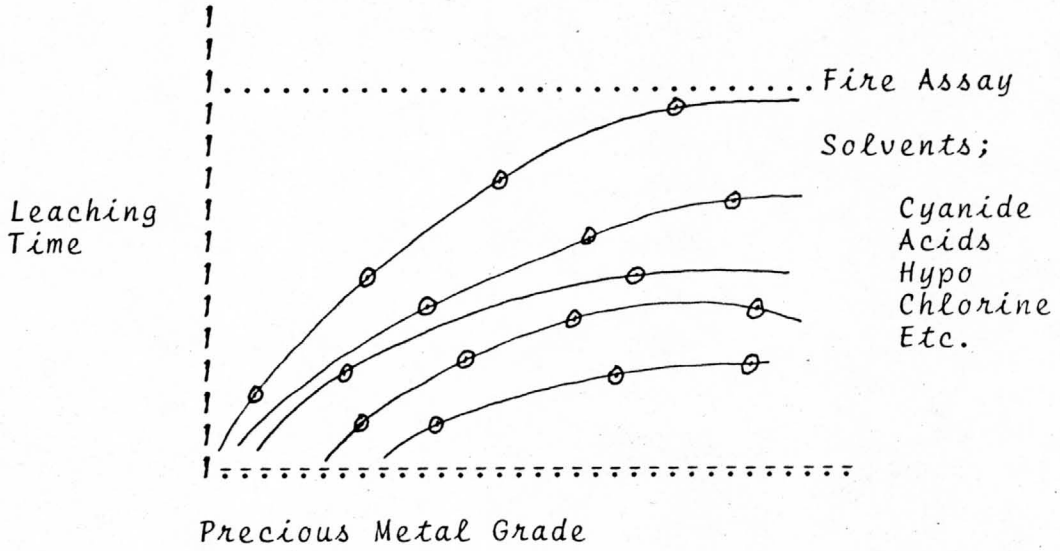
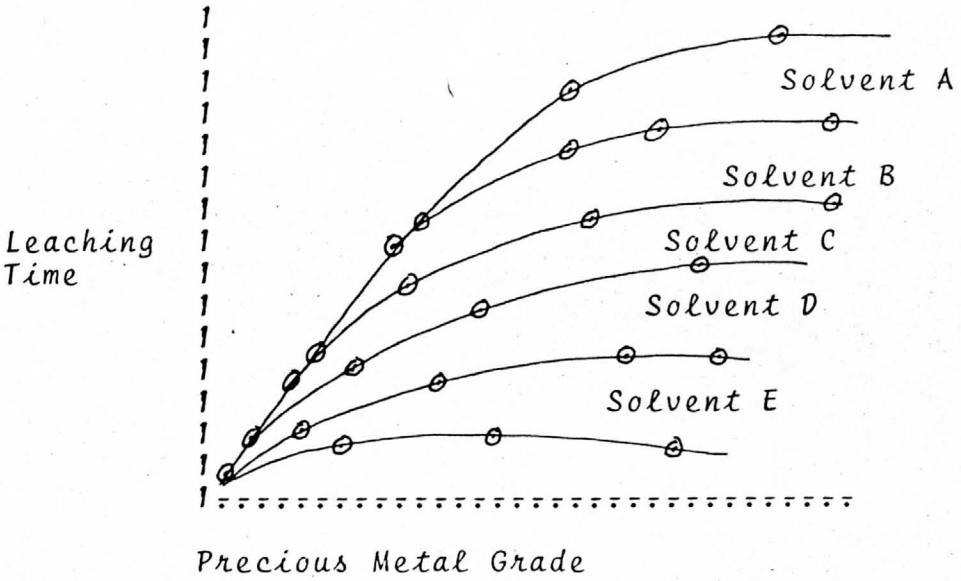
SOLVENT STATIC & DYNAMIC ANALYSIS





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Solvent & Reagent Costs

Solvent or Reagent	Supplier	Form	Price;22 ton load	Unit Price
Ferric Chloride	Sierra(R)	Liq.-42 Be-55 gal drums(625#)	$21/100wgt.	$ 0.21/#
Sodium Chloride	"	Pellets- 50#/$2.88 625# drum-delivered		.16/#
Sodium Chloride	Parsons(SP)	Cry.- 22 ton truck; $3/ton + $6/ton(GF)		$.0045/#
Sodium Sulfide	Sirerra(R)	Flake-20 ton lots Del. WS		.195/#
Lime	" (P)	Hydrated-22 ton lots-Del. WS	$134.43/ton	.067/#
Lime	" (P)	Processed CaO-$37/ton(P)+$5.12/200 miles		.021/#
Caustic	"	Flake Na_2O-500# drum Del. WS		.185/#
Zinc	"	Powd. Merrillite-$68.32/cwt Del. WS		.6832/#
Sodium Cyanide	"	Pellets- Del. WS		.44/#
CaOCl(HTH)	"	Cry. 70%- 1000# lot WS		.70/#
Lead Acetate	"	Powd. 333# WS		$2.34/#
Sodium Thiosulfate	"	100# bags- 22 ton lot Del. WS		.1625/#
Sodium Hypochlorite	"	Liq.- 14%(Cl^-) 55 gal drums Del. WS		.90/gal

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In order to determine the optimum solvent economics, testing must be performed at a comparitive economic concentration, as:

Solvent	Quantitiy for $0.20/ton solution
Cyanide	0.23 gr/ℓ
Sodium Chloride	22. gr/ℓ
Sodium Hypochlorite	421. mℓ/ℓ
Sodium Thiosulfate	.62 gr/ℓ
Ferric Chloride	.48 gr/ℓ
Calcium Hypochlorite	.14 gr/ℓ

Leaching Tests

It was shown in a previous report(June 23, 1978) that the Tombstone ore treated showed the following results:

1. "Natural shooting" of the ore resulted in;
   A. Proper fragmentation for good perculation
   B. Maximum exposure of ore-minerals
2. Ore contained some silver sulfides, and they;
   A. Leach slowly in NaCN
   B. Will leach more completely with an acid pre-tre-tment
3. Leaching rate is good due to a large percentage od Horn Silver.

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Screen Analysis:

Screen Size	Leached Ag Value(t. oz.)/ton
+ 2½ inches	0.25 oz./ton ore
2 "	.80
1½ "	1.10
1 "	1.40
½ "	1.90
¼ "	2.55
1/8 "	3.50
- 1/8 "	6.30

Comparative Leaching Rate and Recovery Rates:

Time	Per Cent Leached		
	Reville	Candelaria	Tombstone
24 hrs.	31 %	83 %	24 %
48 "	65 %	94 %	32 %
72 "	85 %	99 %	43 %
96 "	91 %	100 %	58 %
120 "	98 %		74 %
144 "	99 %		82 %
168 "	100 %		99 %

BARREL TEST RESULTS

Cyanide leach

Test 1:
open pit area

Date	Atom. Adsorp. Au	Atom. Adsorp. Ag
10/14	.004	
	.007	
	.010	
	.015	
	.025	
10/15	.032	
	.042	
	.103	
	.283	
10/18	.308	
	.337	
	.341	
10/19	.490	

Leaching Rate

Date	Au Leached/day
10/14	.025
10/15	.258
10/18	.058
10/19	.149

Test 2:
open pit area

Date	Atom. Adsorp. Au	Atom. Adsorp. Ag
10/7	.007	
	.010	
	.036	
	.044	
10/8	.052	
	.067	
	.075	
10/9	.084	
	.095	
	.100	
10/10	.165	
	.174	
	.180	
10/11	.200	
	.207	
	.222	
10/12	.240	
	.270	
10/15	.301	
	.306	
	.355	
	.379	
	.392	
10/18	.427	
	.431	
	.500	

Leaching Rate

Date	Au Leached/day
10/7	.044
10/8	.031
10/9	.025
10/10	.080
10/11	.042
10/12	.050
10/15	.120
10/18	.108

LIME-CAUSTIC-SODA ASH

Protective Alkilinity

Into three large beakers 500 ml. H_2O was added. Then enough sulphuric acid was added to bring the pH to 2.5(2 ml. H_2SO_4).

Amount of Base Added	pH Lime	pH Caustic	pH Soda Ash
1/4 gr.	3	2.5	2.5
1/2 gr.	5	3.5	5.75
3/4 gr.	8.5	6	6.5
1 gr.	11	8.5	8.5
1 1/4 gr.		11	9.5
1 1/2 gr.			10.5
1 3/4 gr.			11

$$\#/\text{gal.} = \frac{1 \text{ gr. lime}}{500 \text{ ml.}} = \frac{2 \text{ gr. lime}}{\text{liter}} \frac{(3.7853 \text{ liter})}{\text{gal.}} \frac{(\ \#\ )}{453.6 \text{ gr.}} = \frac{.017\ \#}{\text{gal.}}$$

$$\# \text{ lime in south acid pond} = \frac{.017\ \#}{\text{gal}} (1{,}000{,}000 \text{ gal}) = 17{,}000\ \#$$

$$\# \text{ lime/ton ore} = \frac{17{,}000\ \#\ \text{lime}}{24{,}000 \text{ tons ore}} = 0.7\ \#\ \text{lime/ton ore}$$

R. F. HEWLETT
PHONE (702) 731-1601

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TOMBSTONE
METALLURGICAL TESTING

SILVER-SODIUM THIOSULFATE

In order to quantify the effectiveness and economics of sodium thiosulfate($Na_2S_2O_3 \cdot 5H_2O$) as a solvent for silver halides, samples of high-grade silver ore(+7 oz./ton) were collected and analyzed.

Procedure

1. Standard solutions were made with 1,4,10,21,30,40, & 50 grams sodium thiosulfate per liter water
2. 50 ml of each standard solution was placed in a flask with 20 grams of -40 to +64 mesh ore
3. Each flask of "hypo" standard and ore was hand shaken for increments of ½ minute; shaking was uniform
4. After each period of agitation, the flask was allowed to settle for 1½ minutes. Then a Silver determination was made with the AA
5. The flask was then sealed and steps #3 and 4 were repeated until 12 readings were made; 6 minutes of agitation.

Results

1. Leaching rate
2. Silver recovery per gram "hypo"
3. Silver recovery per "hypo" cost
4. Value silver per $1 "hypo".

HEWLETT MANAGEMENT

R. F. HEWLETT
PHONE (702) 731-1601

730 ROYAL CREST CIRCLE S.
APT. 438
LAS VEGAS, NEVADA 89109

METALLURGICAL TESTING

Results of
Sodium Thiosulfate Leaching
of Silver
****

TROY OUNCES AG LEACHED PER TON SOLUTION

Agitation Time (Minutes)	Grams Sodium Thiosulfate per liter						
	1	4	10	21	30	40	50
0.5	.14	.30	.47	.74	1.60	2.63	2.90
1.0	.20	.50	.86	1.37	2.87	3.80	4.30
1.5	.25	.68	1.29	2.04	3.15	4.06	4.60
2.0	.32	.87	1.62	2.44	3.85	4.90	5.58
2.5	.36	.99	1.93	2.83	3.97	4.73	5.53
3.0	.41	1.24	2.20	3.15	4.12	4.80	5.61
3.5	.46	1.33	2.58	3.35	4.18	4.80	5.70
4.0	.55	1.57	2.79	3.69	4.30	4.90	5.70
4.5	.57	1.65	2.95	3.99	4.40	4.82	5.60
5.0	.67	1.90	3.26	3.99	4.39	4.80	5.70
5.5	.69	1.95	3.60	4.14	4.44	4.95	5.80
6.0	.75	2.02	4.12	4.50	4.50	4.90	5.85

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METALLURGICAL TESTING

Silver-Sodium Thiosulfate

Leaching Rate

INCREMENTAL TROY OUNCES AG LEACHED (PER TON SOLN.) PER ½ MINUTE INTERVAL

Grams Sodium Thiosulfate Per Liter	Agitation Time, Minutes											
	Initial ½	1	1½	2	2½	3	3½	4	4½	5	5½	6
1	0.14	0.06	0.05	0.07	0.04	0.05	0.05	0.09	0.02	0.10	0.02	0.06
4	0.30	.20	.18	.19	.12	.25	.09	.24	.08	.25	.05	.07
10	0.47	.39	.43	.33	.31	.27	.38	.21	.16	.31	.34	.52
21	0.74	.63	.67	.40	.39	.32	.20	.34	.30	.00	.15	.36
30	1.60	1.27	.28	.70	.12	.15	.06	.12	.10	.00	.04	.06
40	2.63	1.17	.26	.84	-.17	-.10	-.10	.00	-.08	.00	.15	-.05
50	2.90	1.40	0.30	0.98	-.05	0.03	0.09	0.00	-.10	0.00	0.10	0.05

The above results show the following:

A. Initial "hypo" contact with the silver minerals is the most effective

B. Additional silver is leached with each time increment at low "hypo" concentrations

C. Silver is precipitated out of solution at high "hypo" concentrations.

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METALLURGICAL TESTING

Silver-Sodium Thiosulfate

Silver Recovery Per Gram "Hypo"

The weight per test solution of water, hypo, and ore is computed:

Grams Hypo Per Liter	Wgt. Hypo & H_2O Per Liter	Wgt. 50 ml H_2O	Wgt. 50 ml Hypo
1	1001 gr.	49.95 gr	.05 gr
4	1004 "	49.80 "	.20 "
10	1010 "	49.50 "	.50 "
21	1021 "	48.97 "	1.03 "
30	1030 "	48.54 "	1.46 "
40	1040 "	48.08 "	1.92 "
50	1050 "	47.62 "	2.38 "

From these computations, the recovered Silver per gram Hypo per ton of solution is computed.

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R. F. HEWLETT
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METALLURGICAL TESTING

Silver-Sodium Thiosulfate

OUNCES AG PER TON SOLUTION RECOVERED PER GRAM HYPO

Gr Hypo per Liter	Agitation Time, Minutes											
	½	1	1½	2	2½	3	3½	4	4½	5	5½	6
1	.14	.20	.25	.32	.36	.41	.46	.55	.57	.67	.69	.75
4	.08	.13	.17	.22	.25	.31	.33	.39	.41	.48	.49	.51
10	.05	.09	.13	.16	.19	.22	.26	.28	.30	.33	.36	.41
21	.04	.07	.10	.12	.13	.15	.16	.18	.19	.19	.20	.21
30	.05	.10	.11	.13	.13	.14	.14	.14	.15	.15	.15	.15
40	.07	.10	.10	.12	.12	.12	.12	.12	.14	.12	.12	.12
50	.06	.09	.09	.11	.11	.11	.11	.11	.11	.11	.11	.12

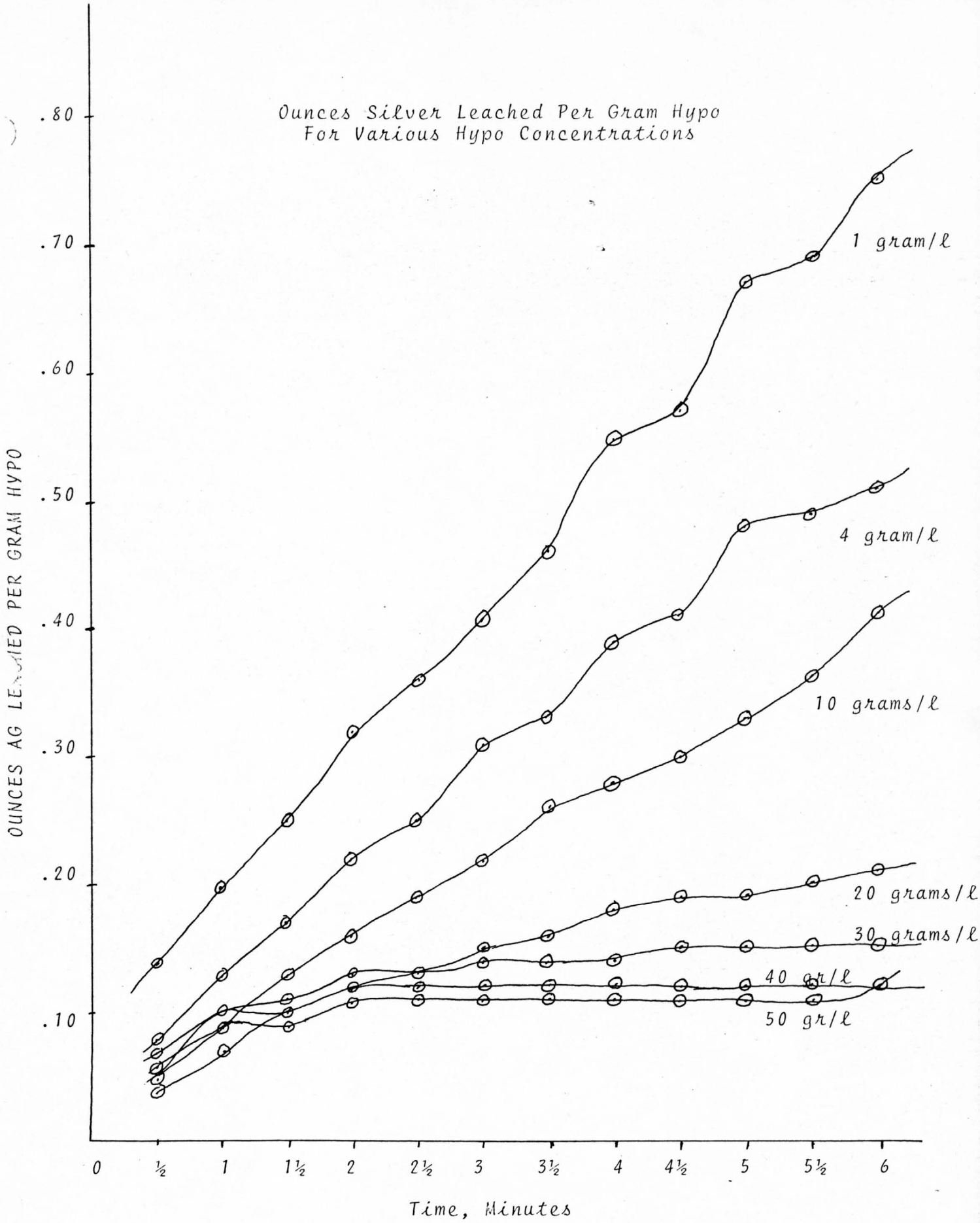
These results have been plotted on the graph on the following page.

The following graph makes the following conclusions obvious:

A. Lowest concentrations of "hypo" are the most efficent

B. Lowest concentrations of "hypo" do not load-up with Ag

C. High concentrations of "hypo" are in-efficient, due to induced chemical precipitation and the possible chemical de-composition of the "hypo".


Ounces Silver Leached Per Gram Hypo
For Various Hypo Concentrations
OUNCES AG LEACHED PER GRAM HYPO
.80
.70
.60
.50
.40
.30
.20
.10
1 gram/ℓ
4 gram/ℓ
10 grams/ℓ
20 grams/ℓ
30 grams/ℓ
40 gr/ℓ
50 gr/ℓ
0
½
1
1½
2
2½
3
3½
4
4½
5
5½
6
Time, Minutes

R. F. HEWLETT
PHONE (702) 731-1601

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METALLURGICAL TESTING

Silver-Sodium Thiosulfate

Economics

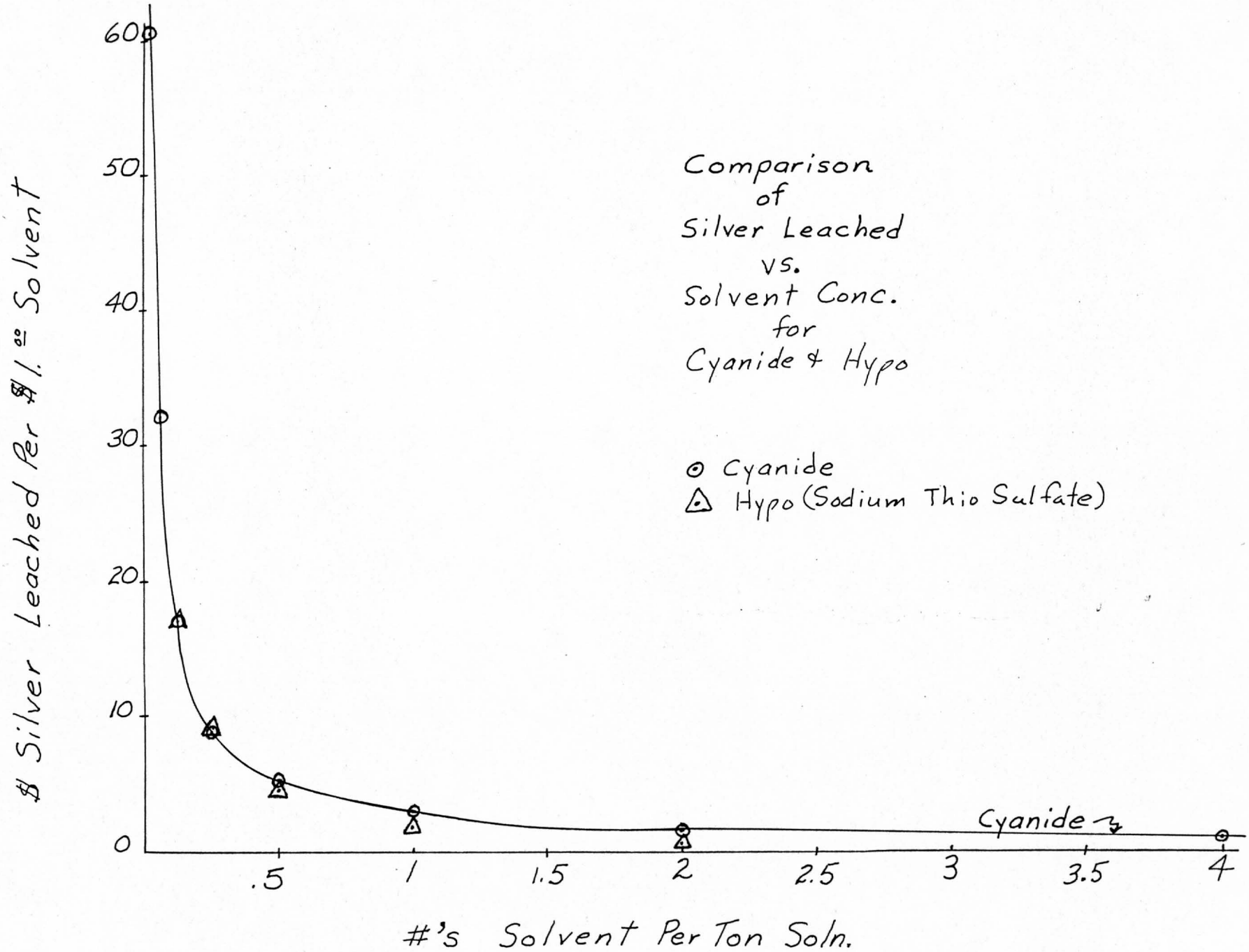
The value of the silver recovered is computed from;

$$\text{Ounces Ag Per 50 ml Solution} = \frac{\text{Ounces Ag}}{\text{Ton Soln.}} \times \frac{\text{Tons Soln.}}{\text{Gr } H_2O/\text{ton}} \times \frac{\text{Gr } H_2O}{50 \text{ ml}}$$

Where; $\text{Gr } H_2O/\text{ton } H_2O = \frac{240 \text{ gal}}{\text{ton}} \times \frac{8.331 \#}{\text{Gal } H_2O} \times \frac{453.6 \text{ gr}}{\#}$

VALUE OF LEACHED SILVER AND PER $1 HYPO

Gr Hypo / l H_2O	T. Oz. Ag / 50 ml soln.	Value Ag @ $5.00	Cost Hypo @ 18¢/#	Ag Recovery $ 1 Hypo
1	.0000413	$.0002065	$.00002	$10.33
4	.0001109	.0005544	.0000794	6.98
10	.0002248	.001124	.0001984	5.67
21	.0002429	.0012145	.0004087	2.97
30	.0002408	.0012039	.0005794	2.08
40	.0002597	.0012985	.0007619	1.70
50	.0003071	.0015354	.0009444	1.63


Comparison
of
Silver Leached
vs.
Solvent Conc.
for
Cyanide & Hypo
⊙ Cyanide
△ Hypo (Sodium Thio Sulfate)
Cyanide
$ Silver Leached Per $1.00 Solvent
#'s Solvent Per Ton Soln.
60
50
40
30
20
10
0
.5
1
1.5
2
2.5
3
3.5
4

Gold Dissolution Rates
(Milligrams Gold Dissolved Per Hour

Equal quantities of gold foil were weighed and allowed to dissolve in various solvents to determine the dissolution rates. After the time to dissolve was observed, the quantity of gold dissolved was checked by titration. Therefore, the rate of dissolution was computed (milligrams Au/Hour), and the dissolution rate cost (milligrams Au/$1 Solvent Cost per ton solution). These results are presented to illustrate:

1. The dissolution rate of cyanide is very slow compared to other halide solvent systems.
2. The relative cost of cyanide compared to halide systems is much higher (for cyanide).
3. Halide system solvents are economic for pre-treatment applications to carbonaceous ores.

Basic to the above is the concept that aurous chloride is insoluble in water but is soluble in sodium chloride. This is based on the following:

A. The initial reaction between chlorine and gold is;

$$2\ Au + Cl_2 = 2\ AuCl$$

B. The rate of solution of the gold is controlled by the rate at which the insoluble aurous chloride film is removed from the surface by the following;

$$AuCl + Cl_2 + Cl^- = AuCl_4$$

and $$AuCl + Cl^- = AuCl_2^-$$

C. The aurous chloride ion is later oxidized to the auric state, but in dilute chlorine solutions this is not the rate-controlling reaction.

Sodium Cyanide

This standard leach solvent produces the following dissolution rates:

Solvent Concentration; # / ton solution	Milligrams Au Dissolved Per Hour
5	2.4
1	3.0
.2	.36

Sodium Chloride-Chlorine System

A standard-brine-solution was prepared using 58.86 pounds of salt (NaCl) per ton solution. This provides an excess chlorine ion. Into this standard brine solution were added various amounts of liquid chlorine. Following are the Au dissolution rates:

Solvent Concentration; # / ton solution	Milligrams Au Dissolved Per Hour
.118	.18
.236	7.2
2.36	108.

Additional tests were made with brine solutions and liquid chlorine because of the application of chlorine to make hypochlorite for carbonaceous ores. An equal amount of gold foil was dissolved in various combinations of concentrations of chlorine and salt. The time to dissolve the gold was divided by the cost of the solvent (per ton solution) to yield a time-of-dissolution vs. cost relationship that allows direct comparison because of the standardization of all of the variables. The plot of these data are presented in the following illustration.

Sodium-Chloride-Chlorine-H_2SO_4 System

The same standard-brine-solution was used with 58.86 pounds of salt (NaCl) per ton of solution. Into this solution were added various amounts of liquid chlorine and sulphuric acid. Following are the Au dissolution rates:

Solvent Concentrations; # / ton solution		Milligrams Au Dissolved Per Hour
Cl_2	H_2SO_4	
.118	5.	7.8
.118	14.	8.4
.236	5.	16.2
2.36	14.	108.6

Chlorine Solution

Two different liquid chlorine solutions were prepared with the following results:

Solvent Concentration; # / ton solution	Milligrams Au Dissolved Per Hour
.874	3.6
4.0	20.4

Chlorine-H_2SO_4 System

Various sulphuric acid concentrations were added to chlorine solutions, with the following results:

Solvent Concentration; # / ton solution		Milligrams Au Dissolved Per Hour
Cl_2	H_2SO_4	
.874	1.6	9.
.874	16.	21.8
.874	20.	37.2

Chlorine Solutions

Various solvents were mixed with chlorine solutions, with the following results:

Solvent Concentration; # / ton solution		Milligrams Au Dissolved Per Hour
Cl_2	Other	
4.	1. Br_2	19.2
4.	4. $CaCl_2$	40.8
4.	16. HCl	225.6
4.	40. Na_2SO_4	19.8
4.	40. NaF	21.

Bromine Solutions

Various solvents were dissolved in bromine solutions with the following results:

Solvent Concentration; # / ton solution		Milligrams Au Dissolved Per Hour
Br_2	Other	
1.	4. Cl_2	19.2
60.	-	110.4
60.	40. NaCl	960.
60.	50. KBr	2220.

Analysis of Various
Gold Solvents

Rank	Solvent Concentration; #/ton soln. Reagent A	Reagent B	Reagent C	Dissolution Rate; Mg. Au/Hr.	Dissolution Mg. Au Per $1 Solvent(s)
1	60. Br_2	50. KBr		2220.	94.9
2	4. Cl_2	16. HCl		225.6	74.2
3	60. Br_2	40. NaCl		960.	60.
4	4. Cl_2	4. $CaCl_2$		40.8	60.
5	4. Cl_2			20.4	51.
6	2.36 Cl_2	58.86 NaCl		108.	41.7
7	.874 Cl_2			3.6	40.
8	4. Cl_2	1. Br_2		19.2	30.
9	.874 Cl_2	1. H_2SO_4		9.	22.5
10	2.36 Cl_2	14. H_2SO_4	58.86 NaCl	108.6	15.7
11	60. Br_2			110.4	7.7
12	.874 Cl_2	16. H_2SO_4		31.8	6.3
13	.874 Cl_2	20. H_2SO_4		37.2	6.3
14	1. NaCN			3.	4.8
15	.236 Cl_2	5. H_2SO_4	58.86 NaCl	16.2	4.1
16	4. Cl_2	40. NaF		21.	2.8
17	.118 Cl_2	5. H_2SO_4	58.86 NaCl	7.8	2.0
18	5. NaCN			2.4	1.9
19	4. Cl_2	40. Na_2SO_4		19.8	1.5
20	.118 Cl_2	14. H_2SO_4	58.86 NaCl	8.4	1.3
21	.2 NaCN			.36	1.3
22	.118 Cl_2	58.86 NaCl		.18	.1

Ionac SR-3 Resin
for
Noble Metals
and Mercury Recovery

Ionac SR-3 is a macroporous chelating resin which is highly selective for precious metals such as gold and others of the platinum group as well as for mercury and methyl-mercury compounds.

Other base metals such as iron, copper, lead, etc. do not react at all with this resin and do not interfere with the selective process. The noble metals are very strongly attached to the resin, yet their recovery presents no difficulty.

Applications

Precious metals are completely removed from solutions containing them (from very high to extremely low concentrations) on passing the solutions through a column of Ionac SR-3.

Use of Ionac SR-3 is recommended for noble metal extraction from ores and wastes, the separation of noble from base metals, the recovery of spent catalysts, the concentration of very dilute solutions containing noble metals and the refining of noble metals.

In addition, Ionac SR-3 is applicable to the removal of mercury(and methyl-mercury) compounds in pollution control.

Example

One microgram of gold dissolved in one liter of slightly acidified water was completely recovered with the aid of Ionac SR-3. Furthermore, even after adding hundreds of milligrams of nickel and copper to the solution, precious metal recovery was complete to the exclusion of the other metals.

Ionac SR-3 also quantitatively collects methyl mercury and inorganic mercury compounds. Both forms are collected from solutions of pH 1-9.

Typical Characteristics

Physical Form: White, macroporous beads
Supplied: Regenerated
Nominal Mesh Range: -16 + 55
Moisture Content: 45% - 55%
Shipping Weight: 750-850 g/l

Capacities

Gold: 150 g/l
Platinum: 65 g/l
Palladium: 58 g/l
Iridium: 25 g/l
Mercury: 150 g/l

General Instructions for Use

1. The pH of the solution coming into contact with the resin should prefereably be adjusted to between 0.5 and 2.5.

2. Adsorption of noble metals or of mercury is carried out at room temperature using conventional ion exchange column techniques. Minimum bed depth should be 750 mm and the flow rate about 10-20 bed volumes per hour.

3. The recovery of the noble metals from the resin is possible in two ways:

   a. Ignition -- Slowly roasting the exhausted resin in air at 900 - 1000° C. leaves the metal in a very pure metallic form.

   b. Elution -- Eluting immediately after adsorption with a 5% aqueous solution of thiourea to which 5 ml/liter of HCl has been added yields a solution from which the metal can be recovered by reduction. When elution is applied, the resin can be reused for many cycles.

4. The elution of the mercury can be also accomplished by treating the resin with 4% sodium sulfide at a level of 200 g Na_2S per liter of resin.

   Following the elution, it is necessary to regenerate the resin by treatment with 10% hydrochloricc acid at a level of 100 g HCl per liter of resin.

TOMBSTONE

Process Chemistry

Activity	Solvent	Reagent	Recovery Method Ag	Recovery Method Au
A. Spray Side Slopes	(1) $Na_2S_2O_3$	None	Powd. Zn	Na_2S
	(2) NaCN	Lime	Na_2S	Resin
B. Crush & Leach No. Ramp	(1) $Na_2S_2O_3$	None	Powd. Zn	Na_2S
	(2) CN	Lime	Na_2S	Resin
C. Crush & Leach Heap (Low-Mn)	(1) NaCℓ	NaOCℓ	Na_2S	Resin
	(2) CN	Lime	Na_2S	Resin
D. Crush & Leach Heap (High-Mn)	(1) NaCℓ	NaOCℓ	Na_2S	Resin
	(2) $Na_2S_2O_3$	-	Powd. Zn	Na_2S
	(3) CN	Lime	Na_2S	Resin
E. Leach heap In Situ	(1) H_2SO_4	None		
	(2) NaCℓ	"	Powd. Zn	Resin
	(3) NaOCℓ	"		
	(4) NaCN	Lime	Na_2S	Resin

"IPS"

INDUCED PERCOLATION

The use of an "Induced Percolation Substance" (IPS) to agglomerate clays and fines greatly enhances the porosity by creating a hard and completely porous agglomerated mass.

In general, Induced Percolation should be used for all heap leaching ores; the technique was originally developed for tailings. Various ores thoroughly tested are Goldfield and Packard tailings, Packard dump and open-pit ore, Tonopah silver ore, Goldfield and Florida Canyon gold ores, and Tombstone open pit, dump, and tailings.

Benefits of IPS are:

1. Percolation increase
2. Percent recovery increase
3. Leaching rate increase
4. Percent slimes in preg pond is minimized
5. Solvent consumption is reduced.

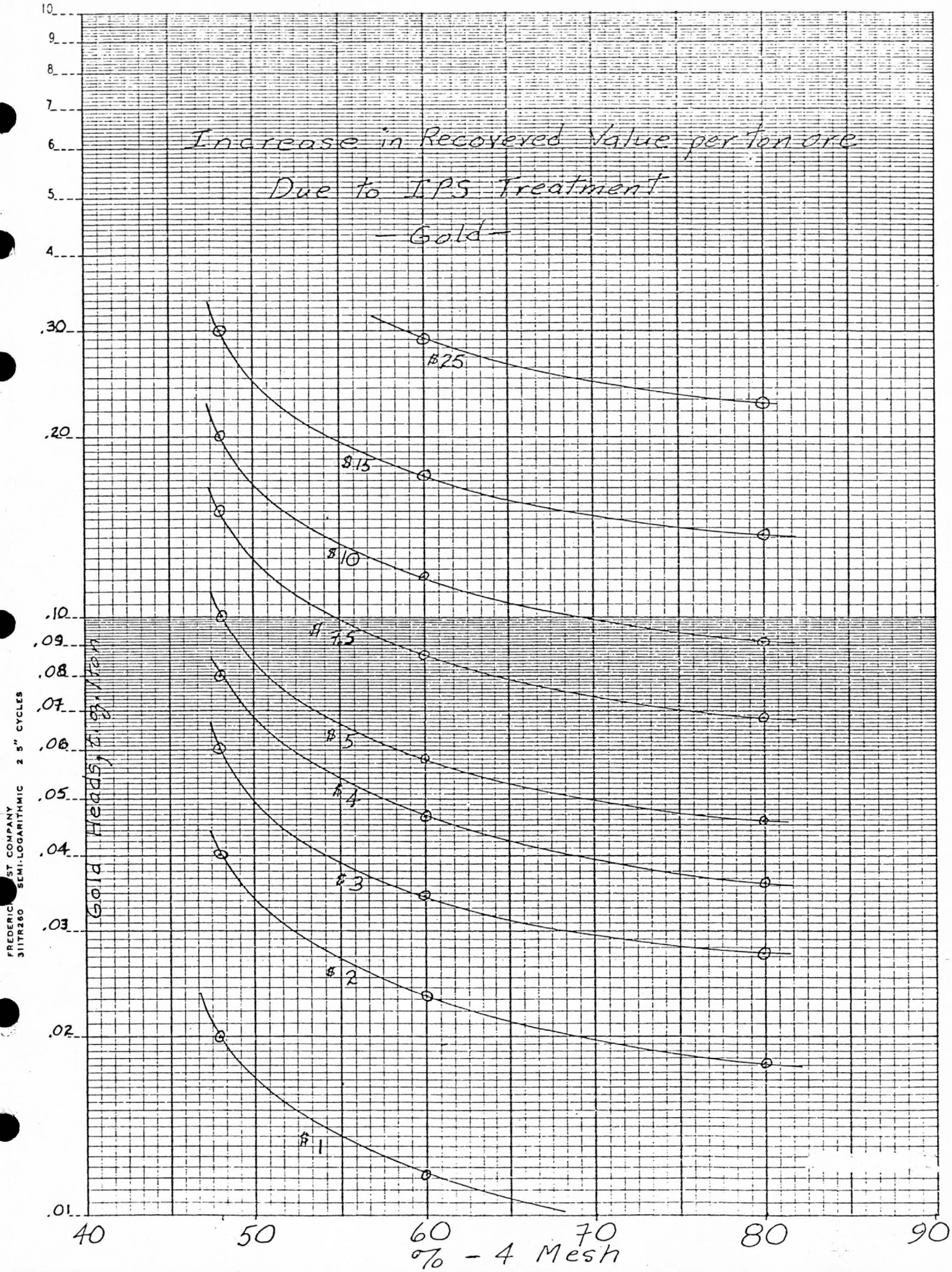
The costs of applying IPS should not exceed $0.50/ton ore. This would apply to tailings. The increased gross value due to IPS treatment ranges from 60 to 35 dollars per dollar IPS cost.

The absolute change (increase) in percolation and consequent recovery due to the use of an IPS can be summarized by the following:

Type of Ore Deposit	Absolute Increase	Per Cent Minus 4 Mesh		
		48%	60%	80%
Gold and Silver	Percolation	45	61	80
Gold	Recovery	25	43	55
Silver	Recovery	26	42	57

The increase in recovered value per ton of ore due to IPS treatment is presented in the following graphs for gold and silver ores.

Notice a positive correlation between the per cent minus 4 mesh and the increase in percolation due to IPS. This rule-of-thumb is very useful for computing the predicted increase in percolation and recovery for various ore types and screen analysis. The methodology for utilization of "Induced Percolation Substances" is presented following the gold and silver increased recovery graphs.


Increase in Recovered Value per ton ore
Due to IPS Treatment
— Gold —
Gold Heads, oz./ton
% - 4 Mesh
$25
$15
$10
$7.5
$5
$4
$3
$2
$1
10
9
8
7
6
5
4
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
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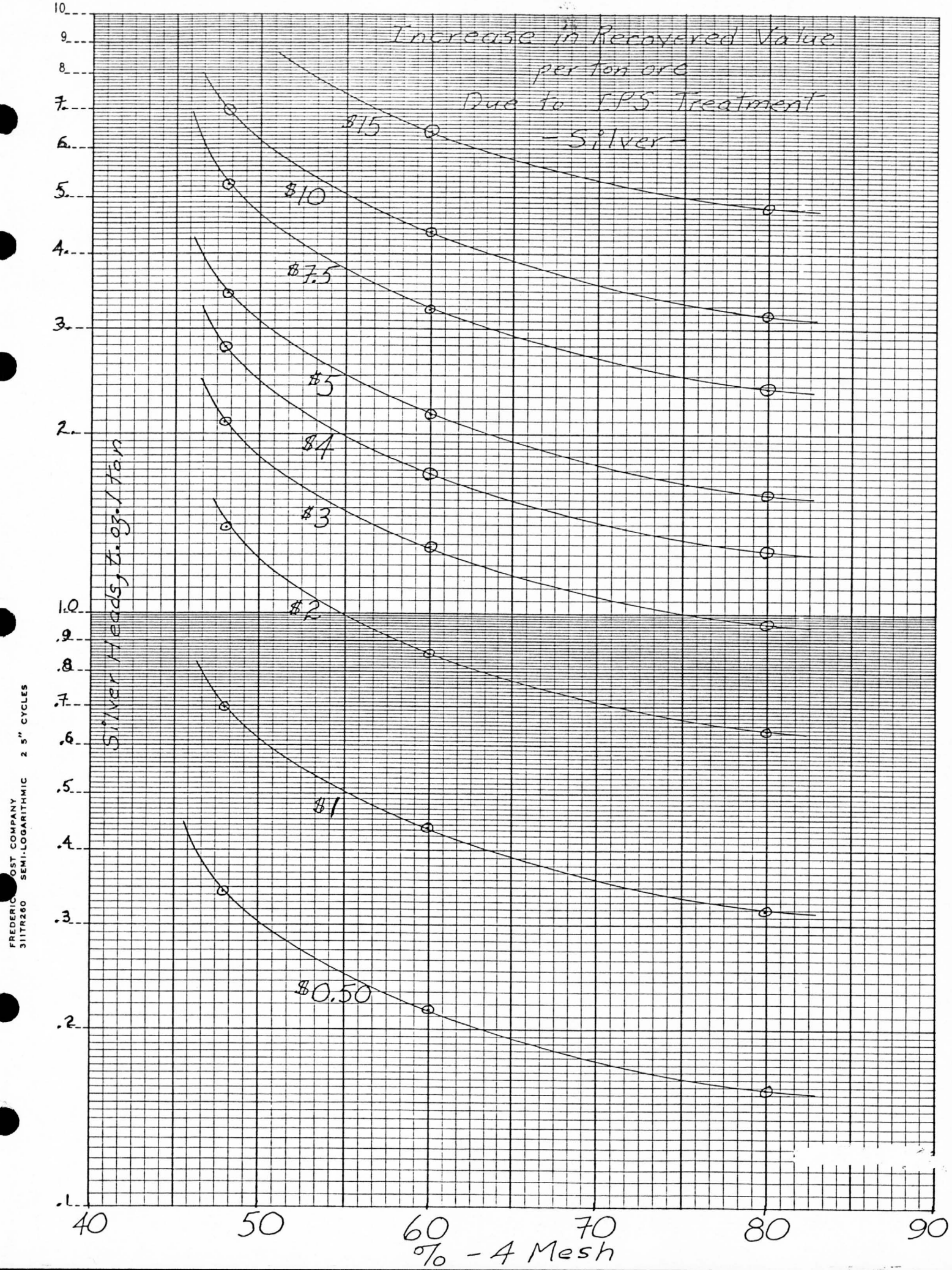
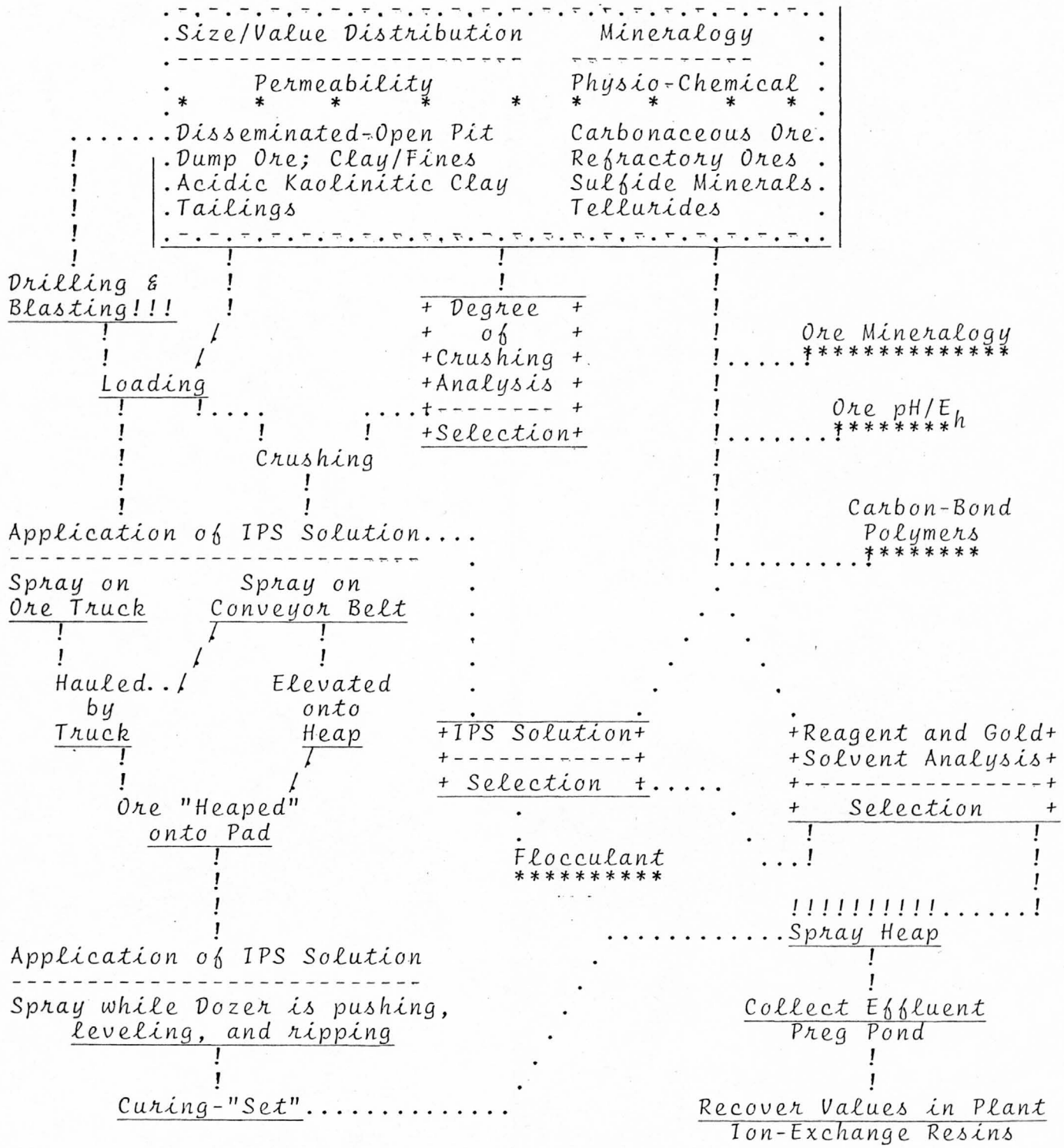
40
50
60
70
80
90
FREDERICK STAST COMPANY
311TR260 SEMI-LOGARITHMIC 2 5" CYCLES


Increase in Recovered Value
per Ton ore
Due to EPS Treatment
- Silver -
$15
$10
$7.5
$5
$4
$3
$2
$1
$0.50
Silver Heads, Z. 03-1 Ton
10
9
8
7
6
5
4
3
2
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
40
50
60
70
80
90
% - 4 Mesh
FREDERICK OST COMPANY
311TR260 SEMI-LOGARITHMIC 2 5" CYCLES

PRE-TREATMENT
of
Various Problem
Precious Metal Ores
for
HEAP LEACHING



PERCOLATION TESTS

Examination of the surface geology at Tombstone indicates that some of the ore will not percolate very well if the blasting is too heavily loaded with prills. Some of the ore will percolate very well; silicified shale, argillite, etc., will either rip or "blast" very easily and will also percolate due to cleavage planes developed during mineralization. However, where there is intense argillation, the developed clays will cause blinding if they are not pre-treated before leaching.

Pre-treatment is a simple technique for clay or fines that trades a small additional initial cost for much higher costs later and a much faster percolation and hence recovery rate. It is therefore very desireable to pre-treat for better percolation to maximize recovery and minimize the leaching period. This is especially useful for a gold deposit with such a high-valued pregnant solution.

Following are the generalized percolation results from the Tombstone tailings. It must be recognized that this represents the very worst case; the drill-hole blasting will not produce all fines, as the tailings represent. However, the study of these tailings in a cyanide-lime solution yields data concerning the effect the fines will have on blinding and relates to the amount of settling required in the preg pond. In addition, a study of the waste dumps determines the parameters of the worst open pit ore.

Notice in table 1 that there are some very poor percolation materials in the upper portion of drill-hole number 2. This "initial stripping waste" (for the initial north pit) will obviously make very good pad material (see later section) if "over-blasted".

Also observed in table 1 are the facts relating to percolation problems the fines will produce in some of the ore intervals. Obviously it is necessary to blast very lightly; load the blast-holes lightly with prills.

It must be pointed out that one of the additional benefits of pre-treatment of the ore to induce percolation is that the fines will be bound together by the "soil cement" and therefore minimize the slimes that would get into the preg pond.

Table 1
DRILL-HOLE PERCOLATION TESTS

Percolation	Drill-Hole		DH Interval	Remarks
Very Bad	TDC-2	(4)	15-20'	Iron Glob-Colloidal
	TDC-9	(35)	170-175'	"
	TDC-9	(36)	175-180'	"
	TDC-24	(11)	50-55'	"
	TDC-36	(19)	90-95'	"
	TDC-36	(20)	95-100'	"
Poor	TDC-2	(5)	20-25'	Slight Separation
	TDC-2	(13)	60-65'	"
	TDC-9	(38)	155-160'	"
	TDC-24	(14)	65-70'	"
	TDC-36	(24)	115-120'	"
	TDC-36	(25)	120-125'	"
Fair	TDC-2	(7)	30-35'	Clear Separation
	TDC-2	(9)	40-45'	"
	TDC-2	(16)	75-80'	"
	TDC-2	(20)	95-100'	"
	TDC-2	(27)	130-135'	"
	TDC-9	(31)	150-155'	"

The above percolation study is a summary of a study made for all logs based on the geology for each drill hole. This percolation study (Table 1) was made from the rotary drill-hole cuttings, which represents the worst case; the blasted ore will not be all fines. A correlation of the cuttings and the blasted ore follows:

Percolation Correlation

Drill-Hole Cuttings	Blasted Ore	Percentage of Ore for Each Percolation Category
Fair	Good	35 %
Poor	Fair	30
Very Bad	Poor	35

Procedure

The use of an induced percolation substance (IPS) to agglomerate clays and fines to greatly enhance the porosity to allow leaching of the total agglomerated mass is a new technique.

Modifications of the basic technique has resulted in even more spectacular results applied to the Tombstone deposit than has been obtained on other ores. Basic modifications initiated by the author are to introduce "TriCalcium Silicates and TriCalcium Aluminates" into the system. The resulting agglomerated mass is hard but completely porous. Another change implemented by the author is to use a standard cyanide leach solution for the "wetting-curing" process, which greatly accelerates the leaching process, or a pre-treatment hypochlorite-halide systems.

SCREEN ANALYSIS

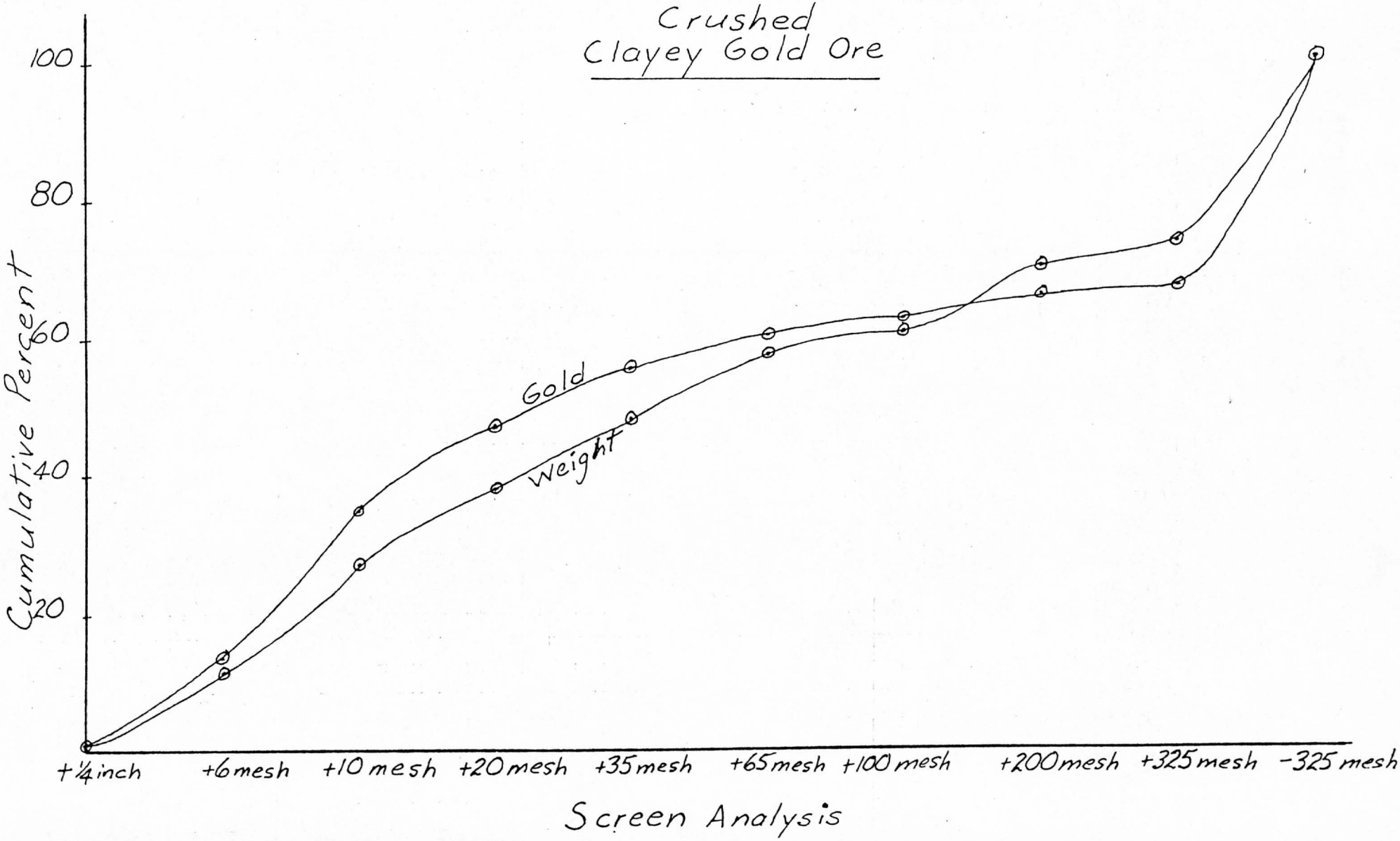
The screen analysis for various size categories is shown in graphs #1 and #1A. Notice that due to crushing (rotary drilling), a close relationship exists between the weight percent and gold-value percent size-distribution. This points out that "induced percolation" would be very effective for getting the values out of the fine fraction; maximization of recovery results from adequate contact of CN and Au in all size fractions, especially in the fines that normally form impermeable "balls" that "lock-up-the-gold-values".

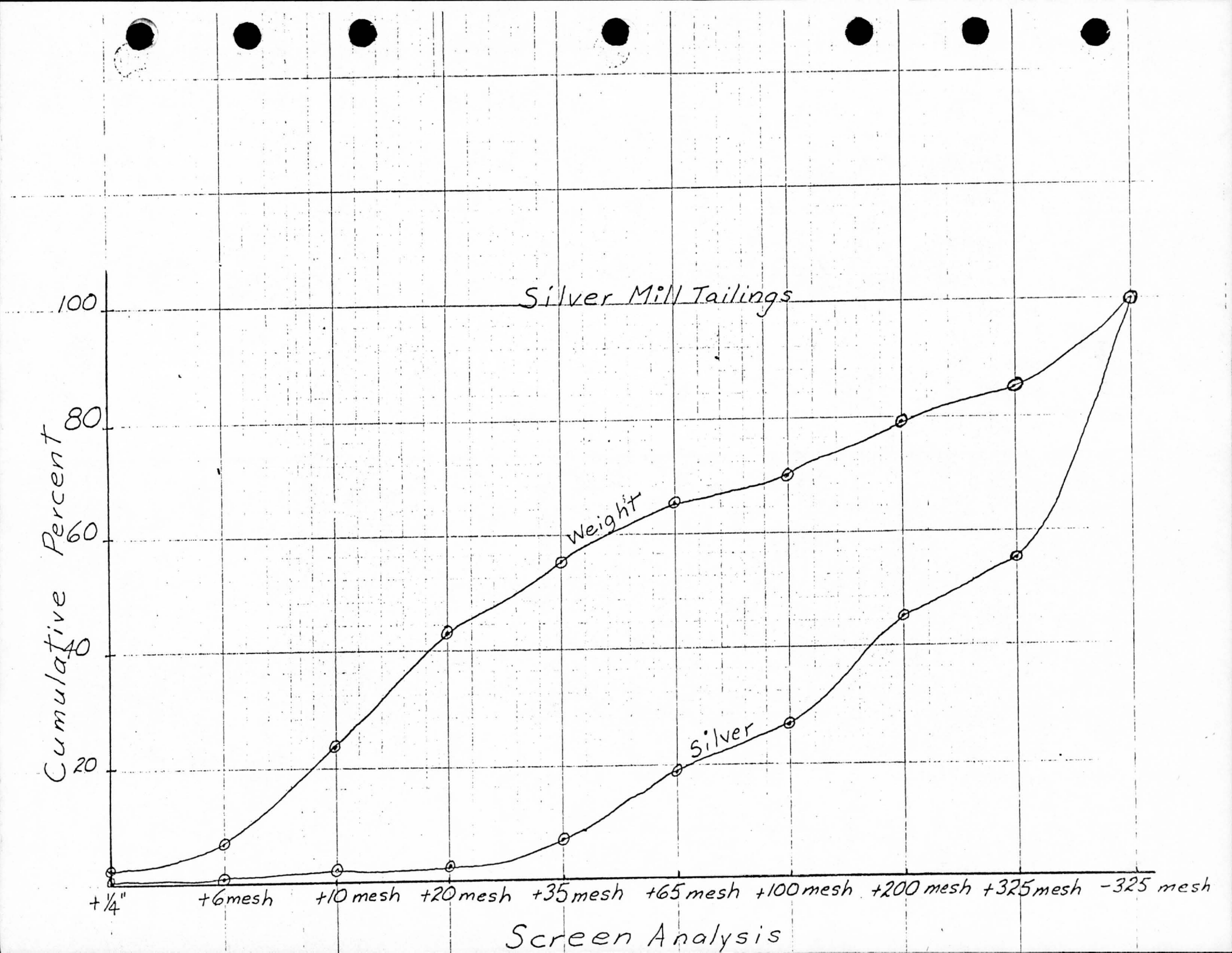
ORE TYPE & CHEMICAL COMPOSITION

The Tombstone ore is slightly basic and requires very little lime/caustic for pH control (protective alkalinity). Chemically, there are numerous clay products in the ore, basically as products of alteration. This furnishes an excess of alumina which requires an excess of hydrated lime for the clay-lime balance. Also, the silica (free) content is not very high, due to the basic lack of silica (free) in the original shale member. Silicification as an alteration product did not furnish "free" silica into the system. There are a great "excess" of iron oxides; limonite and ferric gel-silicate-kaolinite/montmorillinite complexes.

Graph 1.

Crushed
Clayey Gold Ore




Silver Mill Tailings
Cumulative Percent
100
80
60
40
20
Weight
Silver
+1/4"
+6 mesh
+10 mesh
+20 mesh
+35 mesh
+65 mesh
+100 mesh
+200 mesh
+325 mesh
-325 mesh
Screen Analysis

COMPACTED DENSITY

The optimum amount of moisture to add is directly related to the "maximum compacted density" as determined by the standard compaction tests made for highway-pad-soil and other permeability testing procedures.

The concept basic to determining the optimum moisture content for compaction and the resulting compacted density is to compact the test material with varying amounts of moisture into the same known volume (test vessel) and weigh the amount of material that was compacted into the known volume. This yields the "compacted density" and the optimum moisture content is that with the "highest compacted density".

Following is the procedure:

A. Test Vessel Data
   1. Volume
   2. Weight

B. Prepare material with varying moisture contents
   1. Weigh 4 pounds material
   2. Calculate desired moisture content & add H_2O
   3. Mix well

C. Compaction
   1. Add "moist material" in 2-inch lifts & compact
   2. Continue until compacted above collar

D. Separate collar-cut/scrape to top of test vessel

E. Weigh

F. Check "moisture content" computation by weight wet and dry and re-weigh

Following are the results for one example:

A. Test Vessel Data

1. Volume;
   a. Diameter = 3 15/16 inches
   b. Height = 4 9/16 inches
   c. Volume =

$$\pi r^2 h$$

$$= 3.1415927 \left(\left(\frac{3\ 15/16}{2}\right)(1/12)\right)^2 \left(\frac{4\ 9/16}{12}\right)$$

$$= 0.0321507\ ft^3$$

2. Tare weight = 10.380 # or 4708 grams

B. Moisture Preparation (for 4 #'s dry sample);

Required PerCent Moisture-Dry	Ml. H_2O-% Dry for 4 lbs. (1814 gm.)
7	127
8	145
9	163
10	181
11	200
12	218
13	236
14	254
15	272

C. Compaction Test Results

# Wet	% Moisture (Total)	# Net Dry Wgt.	Compacted Dens. Dry #/Ft^3
3.820 #	6.54 %	3.57 #	111.04
3.870	7.40	3.58	111.46
3.910	8.24	3.59	111.59
4.092	9.07	3.72	115.73
4.220	9.91	3.80	118.25
4.237	10.72	3.78	117.65
4.253	11.50	3.76	117.07
4.270	12.28	3.75	116.50
4.200	13.04	3.65	113.60

The results are presented in figure 1, which follows.

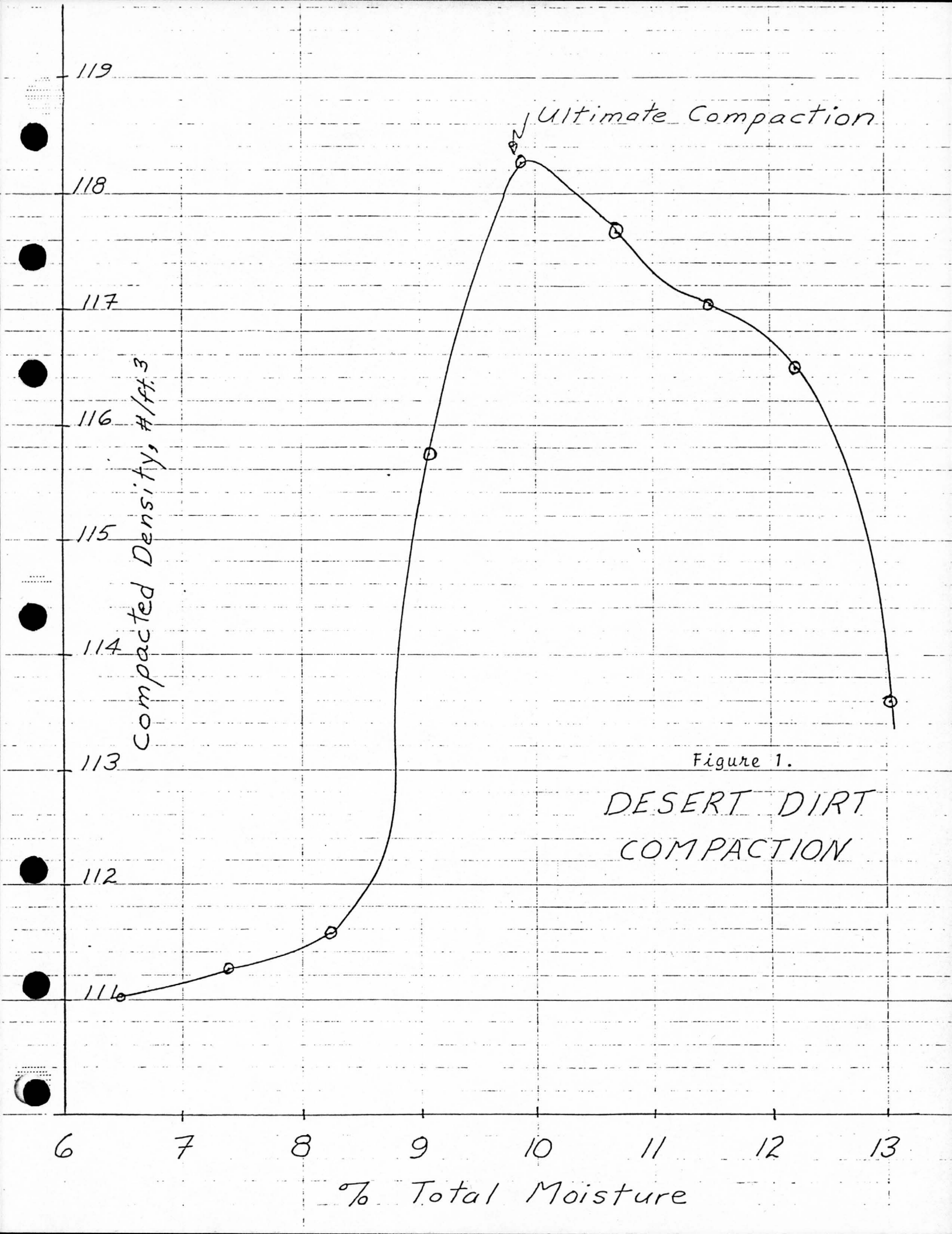


Figure 1.

DESERT DIRT COMPACTION

Local "soil materials" are compared for their maximum compacted density as a guide to determining the optimum moisture content required for determining the optimum moisture-content soil-cement flow rate relationship.

Compacted densities compared locally are from the Florida Canyon area and the "Packard" area, 30 miles to the southwest. The "Packard" material is used as a comparison because of its similar clay composition and screen analysis.

Results of compaction tests in their order of increasing density are as follows (see figure 2):

A. Packard tailings
B. Florida Canyon "crushed ore"-rotary drill-hole cuttings
C. Packard desert dirt
D. Florida Canyon surface waste-clayey material (DH F-2)
E. Packard sub-soil

Notice that the Florida Canyon "waste" is a better pad material than used for a heap-leaching project at Packard (Florida Canyon Pad Material vs. Packard Tailings, which was used for the pad at the Packard property).

From the above results, it is obvious that about 10 % by weight is the optimum moisture content for preparing the "Induced Percolation Material".

TYPES OF IP SUBSTANCES

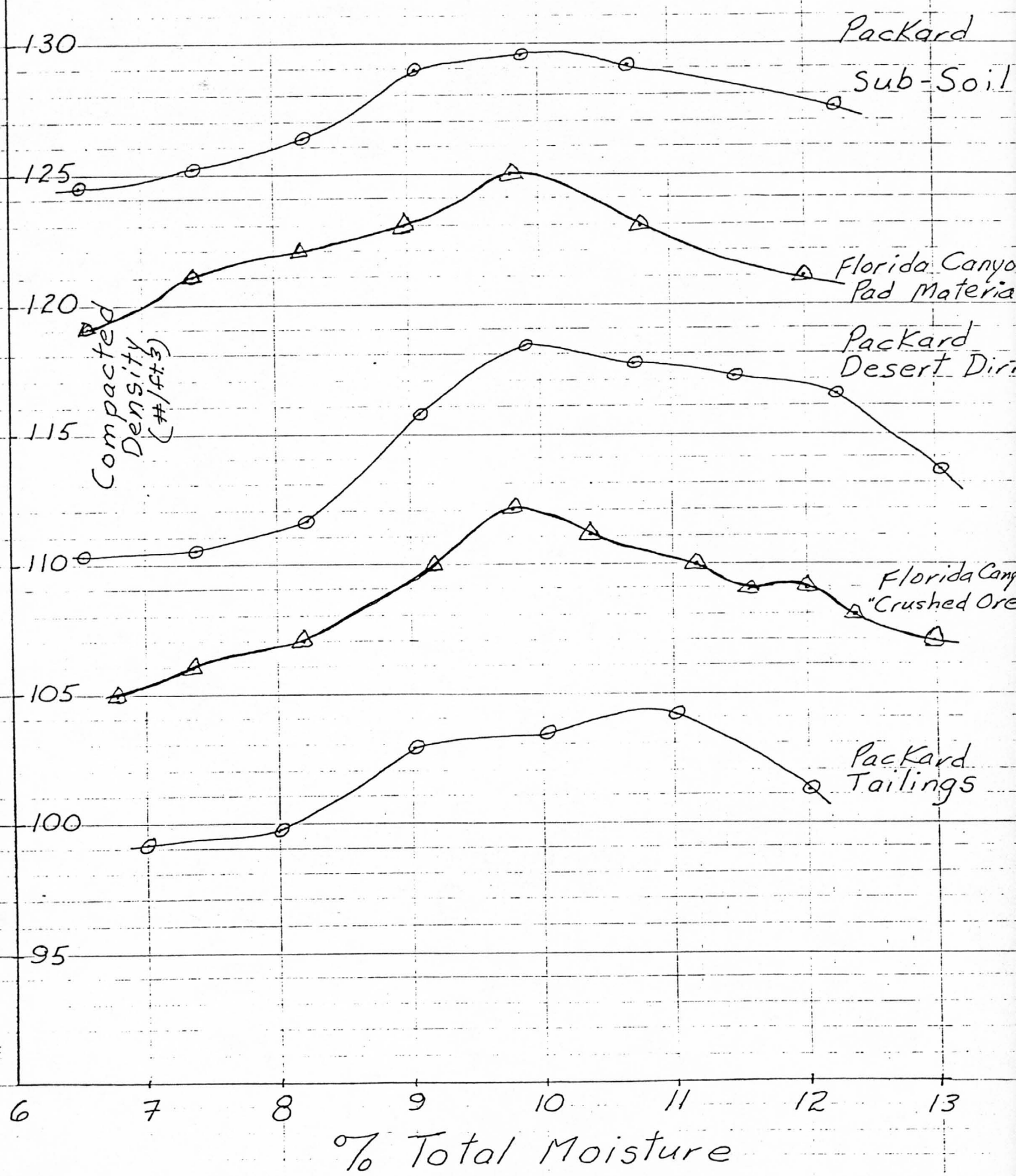
Basic substances that create induced percolation are:

1. Lime (Agricultural, dehydrate, and hydrated)
2. Portland Cement (Types I, II, III, IV, & V)
3. Flocculants (Polyethylene oxide, polymers, etc.)
4. Halides
5. Diatamaceous Earth

The amount of lime (CaO) required for various percolation flow rates are presented in Table 2:

Figure 2.

Compaction Tests



PACKARD MINE

COMPACTION & PERMEABILITY TESTS

Desert Dirt

General Description

"Desert Dirt" was collected along the road and compaction tests were made using the material as it exists-unscreened (the largest coarse was 1-1/2 inches).

Clay Swelling

There has been no rain for four months. The desert dirt was dried for 24 hours with no moisture loss, indicating a very dry condition. The pan + sample weight before and after drying was 6.241 #, with the pan weight = 1.885 #.

The moisture retained in the clay lattice by the clay in the desert dirt after 24 hours drying is computed as follows:

Prepared % Moisture-Dry Weight	Calculated % Moisture, Total	Pan & Sample Weight Wet	Pan & Sample Weight Dry	PerCent Retained Moisture
7	6.54	5.730	5.450	12.0 %
8	7.40	5.750	5.409	17.6
9	8.24	5.790	5.429	12.8
10	9.07	6.048	5.642	9.1
11	9.91	6.049	5.609	8.2
12	10.72	6.050	5.577	7.2
13	11.50	6.051	5.544	6.3
14	12.28	6.052	5.512	5.3
15	13.04	6.053	5.479	4.4

Table 2
DEHYDRATED LIME VS. LEACH FLOW

Amount of Lime	Flow Rate (Gal/Hr/Ft^2)	Rate of Change Gal/Hr/Ft^2/# Lime
0	.5	
0.5	1.12	1.24
1	1.78	1.32
2	2.94	1.16
3	4.00	1.06
4	5.60	1.60
5	5.96	.36
6	6.72	.76
7	7.36	.64
8	7.78	.42
9	8.17	.39
10	8.58	.41
11	8.71	.13
12	8.83	.12
13	8.96	.13

Notice that the optimum amount of dehydrated lime is about 4 pounds/ton ore. Hydrated lime was also tested with better success (required less hydrated lime/ton ore). However, the best and most economical results were obtained by using hydrated lime and "Portland-type cement".

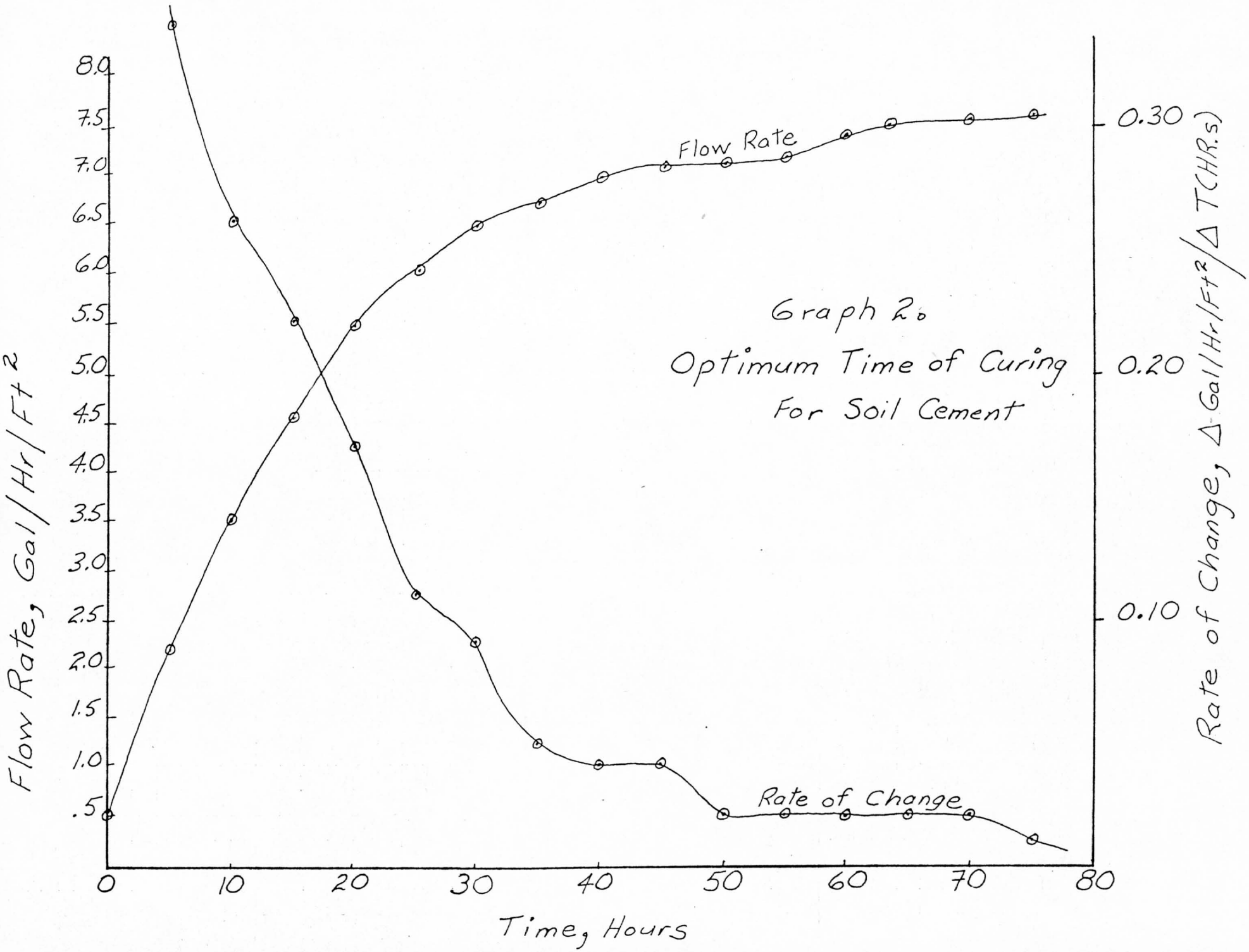
PROPORTIONING ANALYSIS

The above proper amounts of the IP substances are combined according to their screen analysis and chemical composition to produce the proper plasticity index.

CURING TIME

The optimum "curing time" for the Tombstone soil-cement is shown in graph 2. Notice that after 35 hours, the rate of change of the flow rate is very minimal.

The above described procedure is summarized in the illustration following graph 2.


Graph 2.
Optimum Time of Curing
For Soil Cement
Flow Rate
Rate of Change
Flow Rate, Gal/Hr/Ft²
Rate of Change, Δ Gal/Hr/Ft²/Δ T(HRs)
Time, Hours
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.30
0.20
0.10
0
10
20
30
40
50
60
70
80

INDUCED PERCOLATION SUBSTANCES

ORE TYPE
****

Acid Basic

Clay
Tailings

TYPES OF IP SUBSTANCES
****

Lime
- Agricultural
- Dehydrated
- Hydrated

Portland Cement
- Type I
- Type II
- Types III, IV, V

Diatamaceous Earth

Flocculants

Halides

ORE CHEMICAL COMPOSITION
****

Silica
Alumina
Silicates
Iron Oxides
CaO & MgO

PROPORTIONING ANALYSIS
****

Plasticity Index
Screen Analysis

CURING
******

Time
Method

SOLUTION QUANTIFICATION
****

Compacted Density
Application Techniques
Solvent(s)

ECONOMIC ANALYSIS
****

Maximize;
- Percolation
- Heat of Hydration
- Recovery Rate of Precious Metals

Minimize;
- Disintegration
- "Set Time"
- Cost per Ton

Results

Agglomeration of the ferric aluminum silicates (limonitic clays) occurred with the agglomeration (soil cement) possessing excellent porocity. The optimum level for each of the parameters is as follows:

Parameter	Optimum Level	Remarks
Ore Chem Comp.		
Clay	Excess H_2O	About 9 % extra
Clay	Excess Hydrated Lime	Extra pound
Ferric Oxides	Excess Hydrated Lime	With above 1-1/2 #
Moisture Content	10 % by weight	Allow for clay swelling
IP Substances		
Hydrated Lime	10 #/ton ore	Max.; varies for consi
Portland Type II	3 #/ton ore	or screen analysis
Flocculant	.02 #/ton ore	Depends on above
Diatamaceous Earth	4 #/ton ore	

ECONOMIC ANALYSIS

The following table (3) presents the results of the induced percolation study for Tombstone ore. The results all indicate the very great economic advantage of treating to some degree (depends on natural percolation-screen analysis) all ore from the property.

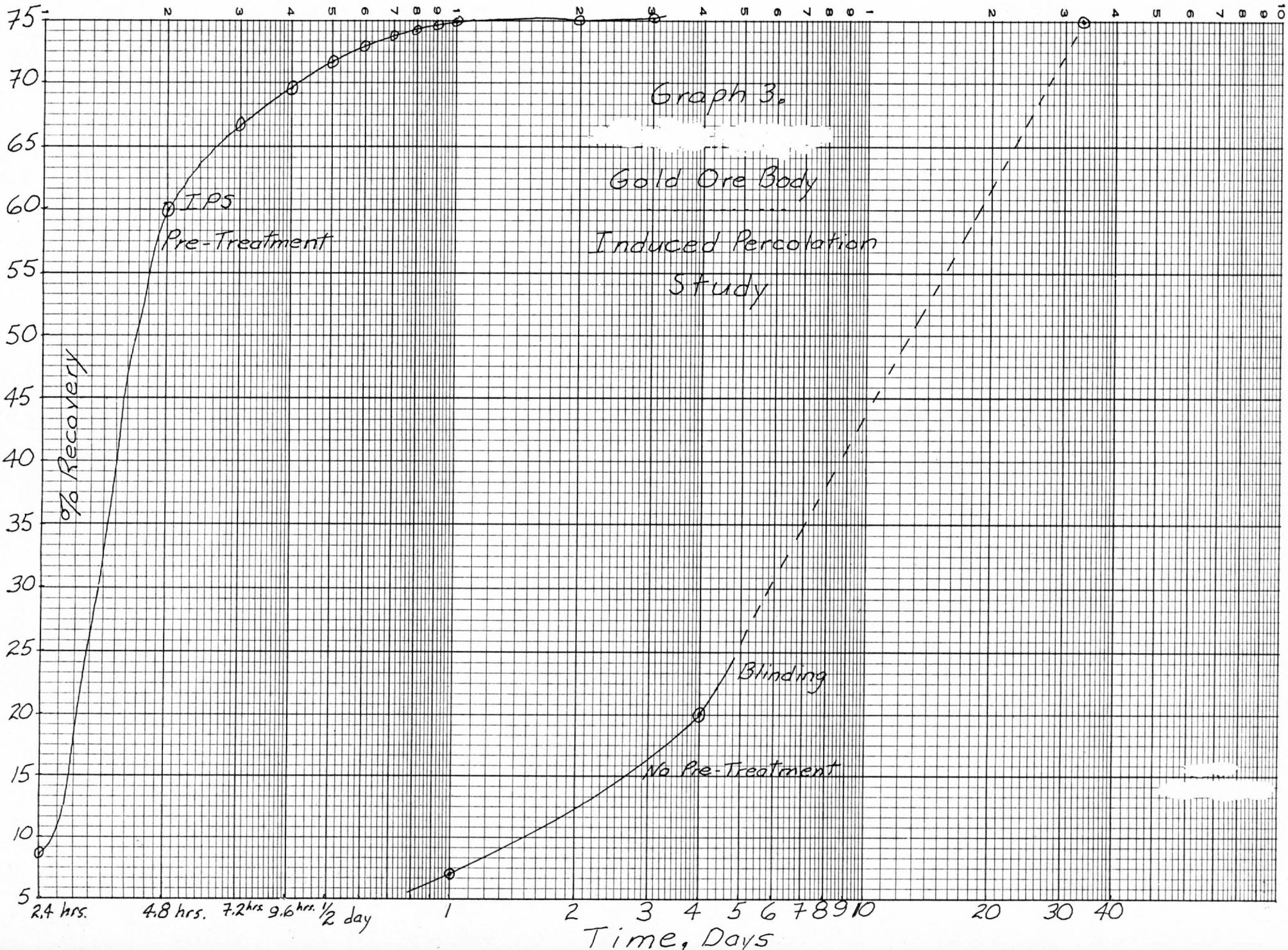
Graph 3 presents the summary of the percent recovery for various leaching periods for treated vs. un-treated ore. Notice that IPS treatment results in total leaching (recovery) in one day versus a projected 33 day leach for the untreated ore. This is to say that after blinding in four days, additional dozing, ripping, and other very costly secondary recovery methods <u>may</u> result in as much recovery as the IPS treated ore obtained, but it would take 33 days vs. one day.

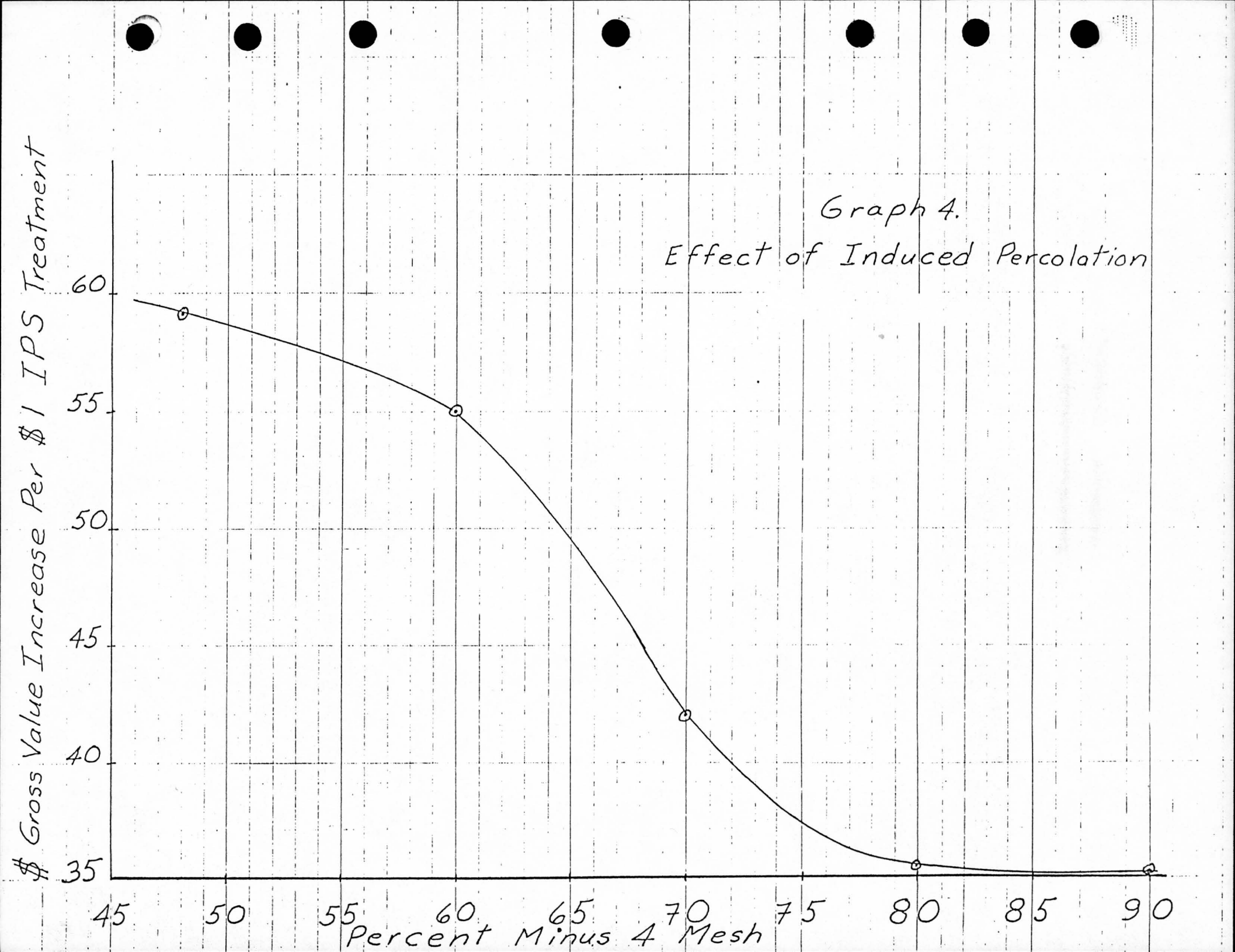
Graph 4 presents the results of the use of IPS, showing the gross value increase due to IPS per $dollar IPS treatment. It is shown that greater increase in gold value resulted in modest application for coarser material than all fines.

Table 3
ECONOMIC ANALYSIS
INDUCED PERCOLATION
Tombstone

PARAMETER	PERCOLATION		
	Good	Fair	Poor
% Minus 4 Mesh	48 %	60 %	80 %
% Tonnage	35 %	30 %	35 %
% Recovery;			
Treated	75 %	75 %	75 %
Un-Treated	50 %	32 %	20 %
Gross Value/Ton;			
Treated	$12.20	$12.20	$12.20
Un-Treated	8.13	5.21	3.25
Difference	4.07	6.99	8.95
Quantity/Ton;			
Hydrated Lime	1/2 #	1 #	2 #
Portland II	1/2 #	1 #	2 #
Flocculant	.01 #	.01 #	.02 #
IPS - Cost;			
Hydrated Lime	$ .037	$ .074	$ .148
Portland II	.021	.043	.085
Flocculant	.010	.010	.020
	.068	.127	.253
$ IPS Increase (GV) / $ IPS Treatment	$59.9	$55.0	$35.4

FREDERICK [illegible] COMPANY
311TR334 SEMI-LOGARITHMIC 3 3-1/3" CYCLES




Graph 4.
Effect of Induced Percolation
$ Gross Value Increase Per $1 IPS Treatment
60
55
50
45
40
35
45
50
55
60
65
70
75
80
85
90
Percent Minus 4 Mesh

BARREL LEACH TESTS

Wgt. (Dry) Ore 49.5# (A)
Wgt. Barrel + Tray _____ (B)

Un-Treated Ore

Lime added (gr.) 2 gr -> pH + 10.5

Time	Total Wgt. (A+B+Soln.)	Wgt. Soln.	AA/Ton Soln. Au	AA/Ton Soln. Ag	(Wgt. Soln.) / (Wgt. Ore)	Au Per	Ag ton ore
4		64.08#	.002	. -	1.295	.002	. -
8	BLINDING	65.36	.002	. -	1.320	.003	. -
12	BLINDING	62.18	.004	. -	1.256	.005	. -
24	Blinding	65.11	.005	. -	1.315	.006	. -
96	Severe Blinding	64.48	.012	. -	1.303	.016	. -
Not The Same	Added Hyd. Lime	65.37	.043	. -	1.321	.057	. -

BARREL LEACH TESTS

Wgt. (Dry) Ore 40.0 (A)
Wgt. Barrel + Tray _____ (B)

"IPS" Pre-Treatment

Lime added (gr.) 2 gr - pH = 10.5

Time	Total Wgt. (A+B+Soln.)	Wgt. Soln.	AA/Ton Soln. Au	AA/Ton Soln. Ag	(Wgt. Soln.) (Wgt. Ore)	Au Per	Ag ton ore
.1 Day		63.40 #	.004	. -	1.585	.007	. -
.2 "		61.46 #	.032	. -	1.5365	.049	. -
.3 "		64.20 #	.034	. -	1.605	.054	. -
.4 "		63.96 #	.035	. -	1.599	.056	. -
.5 "		62.10 #	.038	. -	1.5525	.059	. -
.6 "		62.83 #	.038	. -	1.57075	.059	. -
.7 "		62.63 #	.038	. -	1.56575	.060	. -
.8 "		61.25 #	.039	. -	1.53125	.060	. -
.9 "		61.75 #	.040	. -	1.54375	.061	. -
1 Day		62.30 #	.039	. -	1.5575	.061	. -

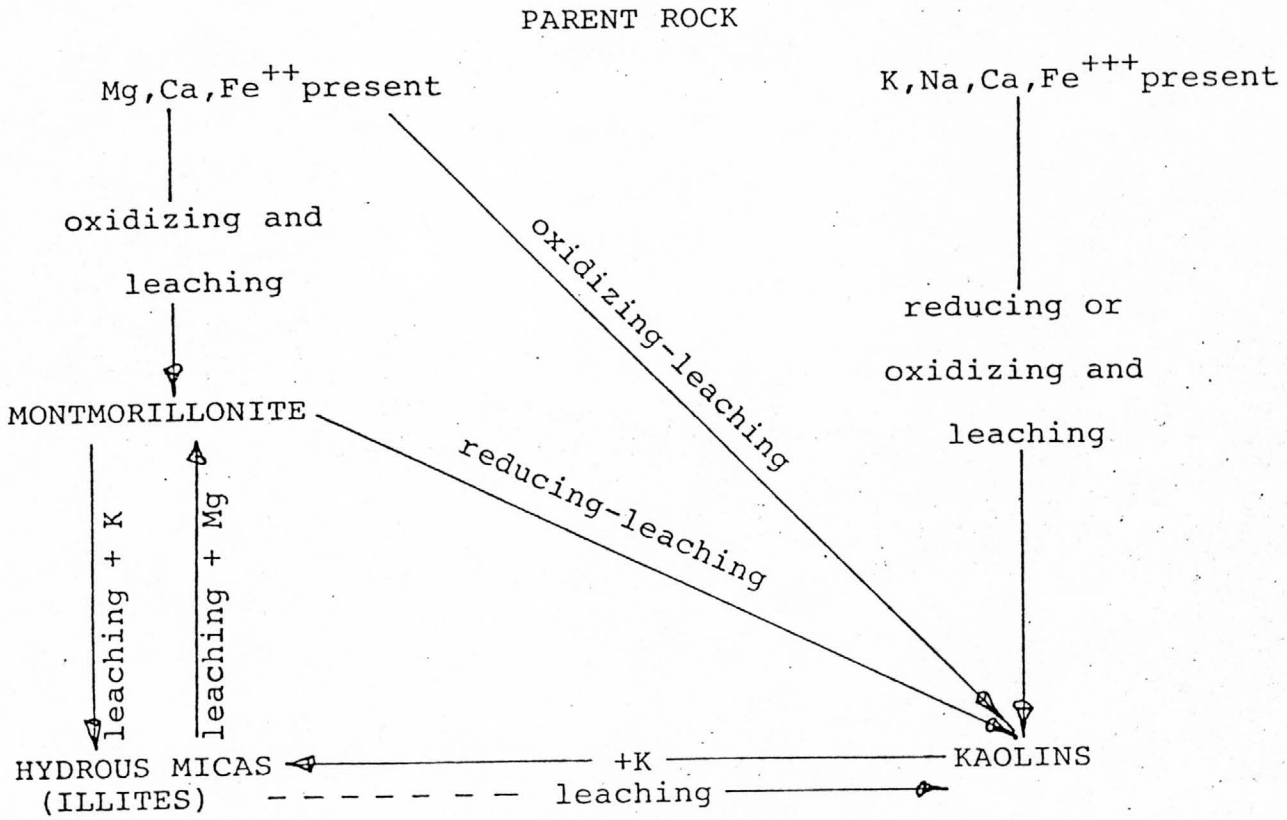
CLAY TECHNOLOGY

R.F.Hewlett
June 28, 1977

Clay minerals commonly formed are:

1. Kaolins
2. Montmorillonites
3. Illites(Hydrous Micas).

Starting from any parent rock, the clay minerals develop under specific environmental conditions as shown below:



The previous diagram illustrates the following:

1. Clay minerals are very sensitive to small changes in the composition, temperature, and pH of their surroundings(excellent indicator minerals)
2. Clay minerals are not stable end products of weathering but are part of a system existing in dynamic equilibrium with its components. The rate at which many of the clay minerals react to environmental changes is often very rapid.
3. Kaolinite characteristically develops in an acid environment often produced by organic acids or the oxidation of sulphide minerals. Also, strong leaching under neutral conditions where the bases have been removed from the rocks develops kaolinite.
4. Montmorillonite minerals develop under a wide range of conditions.
5. Illites are the dominant clay minerals in marine sediments, but they also occur in certain soils derived from marine shales.

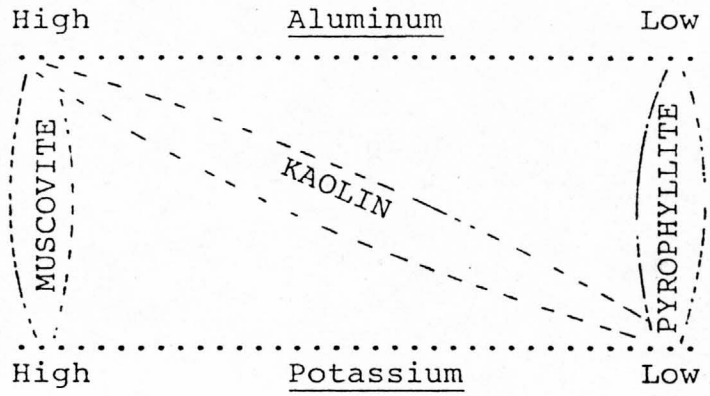
<u>Kaolinite</u> ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)

Synthetic modes of formation:

Temp.	Time	Solvent	Substance
320°C	24 hrs.	o.5N HCl	Orthoclase($KAlSi_3O_8$)
16	96 "	dil. HF	"
300	250 "	o.5-1.oN HCl/H_2SO_4	"

The pH ranges of formation are:

ACID	NEUTRAL	BASIC
Kaolin	Kaolin	Montmorillonite
********	******	**********
Ions with alkali metals(Li,Na,K,Rb,Cs)	'Free of 'Alkali 'Metals	Alkali:Al_2O_3:SiO_2
(4.5-5.2 pH with opt. range 4.8-5.0)		.o2-1: 1 : 4
		Alkali's can be;
High Al/SiO_2 ratio & Potassium Conc.		NaOH, KOH, $Ca(OH)_2$



CLAY MINERAL SPECIES

1. Micaceous Clay Minerals

   a. Kaolinite Group

      Dioctahedral
      - Kaolite
      - Halloysite, $2H_2O$
      - Hydrated halloysite, $4H_2O$
      - Nacrite
      - Dickite

   b. Montmorillonite Group

      Dioctahedral
      - Montmorillonite
      - Beidellite
      - Nontronite

   c. Hydrous Mica Group

      Dioctahedral
      - Illite
      - Pinite
      - Glauconite
      - Celadonite
      - Brammalite

   d. Mixed Layer Group

      - Anauxite
      - Bravaisite
      - Vermiculite-chlorite
      - Kaolinite-nontronite
      - Montmorillonite-illite

Synthetic Formation

MONTMORILLONITE:

Montmorillonite + $KHCO_3$(10%) + H_2O ---> Orthoclase

Add heat in gold-lined pressure bomb (KAcid Carbonate)

ALUNITE:

A. $H_2SO_4 + K_2SO_4 + Na_2SO_4))_{.01M} + NH_4SO_4$ --> Alunite

60-90% Alunite in 7 days at 200°C

B. 50g $AlSO_4$ + $((H_2SO_4 + K_2SO_4 + Na_2SO_4))_{.05M}$ ---> Alunite

50-99% Alunite in 100 days at 100°C

HALLOYSITE:

Kaolinitic clay + $SO_4^{--}))$ ---> Halloysite

Within carbonate rocks;
therefore a pH change

KAOLIN:

Solfataric Action: ((Alkali)) + SO_2 + S_2 + HCl ---> Kaolinte
Metal
Soln.

Solubilities

A. Mullite ($3Al_2O_3 \cdot 2SiO_2$) is slightly soluble in cold H_2O

B. Montmorillonite Groups disolve in a weak acid soln.
(0.01 - .04% H^+)

Decompositions

A. Kaolin

$$\text{Kaolin} + H_2SO_4 \text{))}_{\text{strong}} \longrightarrow SiO_2 + AlSO_4$$

Properties of $Al_2(SO_4)_3$;

A. White powder
B. Soluble in cold H_2O - 31.3 gr/100 ml (o)
C. Soluble in hot H_2O - 98.1 gr/100 ml (100)
D. Slightly sol. in dil. acid and alcohol

Ionization

Calcium from soil colloids*

Clay + NaOH + $Ca(OH)_2$ ---> change in clay lattice;

Therefore, kaolinite + NaOH + $Ca(OH)_2$ ---> Montmorillinite

(Gives up ionized "salts")

Permeability

Calcium - saturated clays tend to be granular & comparatively pervious with Ca; Na clays are highly dispersed and impervious

Base Exchange

Influences pH:

A. Ca clays if free from $CaCO_3$ are 7
B. Na clays are highly alk. - +10
C. Rain with dis. CO_2 is acid(H^+) and H ions replace Na and form dil. soln.s of $NaHCO_3$-Na_2CO_3 or NaOH; resulting in increased alkalinity of Na clays
D. Mix; Na clay + $CaCO_3$ ---> alkiline upon leaching

(Ca^{++} replaces Na^{++} + Na_2CO_3
Also, Mg replaces Na...

Ion Exchange

Clays can be considered as multivalent polyelectrolytes in ion exchange reactions. The key for each of the major crystal structure groups are the distribution of charges in the lattice.

Members of the kaolin group have as a site of exchange reactivity the structural hydroxyl ions along the lateral surfaces and those formed by the hydration of silica at the broken edges of the crystals.

Montmorillonite clay groups are the most active in terms of ion exchange reactivity per unit weight. Either magnesium substitutes for aluminum or aluminum for silicon.

Illite group of clay minerals fix potassium irreversibly.

Processes that occur in an aqueous clay-electolyte interaction:

A. Ion exchange
B. Work of swelling
C. Water transfer
D. Donnan exclusion of anions
E. Complex ion formation
F. Incomplete dissociation
G. Ion pair formation
H. Molecular adsorption
I. Change in solution volume.

Clay Strucure Stabilization

Polar organic compounds play two important roles in soil structure:

1. Weakening the potentially strong cohesive bonds between clay particles(thus permitting formation into aggregates)
2. Linking clay particles together through mutual adsorption of such compounds by two or more clay particles.

Compounds very important in soil structures are polyuronides and polysaccharides. They are readilly adsorbed by clay molecules.

To produce a permeable clay, Na^{+} must be replaced with Ca^{++} (to produce flocculation). Colloids in non-alkali soils tend to flocculate. Both Ca^{++} and H^{+} ions produce flocculation and absorption of most polar organic molecules causes complete flocculation. (Soil structure changes are in degree of expression of cohesive forces between already flocculated clay particles).

Organic matter modifies the plasticity of clays by utilizing its bulk and adsorptive capacity to adsorb water and insulate or coat clay particles, and by direct adsortion the polar organic compounds modify cohesive forces and bind clay particles together so they are not free to move and thus are less plastic.

Impermeable Soil Conditioning

Polmethracrylates and other correctives for impermeable clays include amino compounds and Krilium-like compounds(polymers).

In general, Krilium-like molecules are large anions and polyanions adsorb on Kaolinites. Amino compounds are large cations and polycations adsorb on Montmorillonite and Beidellic clays.

The Krilium-like molecules are adsorbed by hydrogen bonding. Some of these made by Monsanto Chemical are:

A. CRD 186; a Ca-saturated Krilium
B. CRD 189; a Na-saturated Krilium.

One observation made is that 0.1% of a Krilium-type compound is equivalent to a 2% calcium hydroxide solution in reducing swelling pressure and increased stability. However, higher percentages of calcium hydroxide produced more significant results.

Ammonium ion and phosphate fixation are commonly utilized for soil fixation. Kaolinite and halloysite can adsorb phosphate ions by replacement of hydroxyl groups on the surface of the clay.

The adsorbed phosphate ions on kaolinite could be replaced by arsenate ions. The anion exchange capacity is about equal to the cation exchange capacity. Both the phosphate and arsenate ions are tetrahedral in form like silica, and evidently can attach themselves to the broken edge of the silica sheet and act as an electrically unbalanced silica tetrahedron. A negative anion adsorption is developed for chloride, sulfate, and ferrocyanide in montmorillonite minerals. Formate ions are also adsorbed by H-montmorillonite by treating with formic acid.

DESIGNED TESTING PROCEEDURE

Pre-Treatment

A. Basic

1. CaO (lime)

   Add 1,2,3,4,&5 #lime/ton ore and note effect on perculation.

2. $Ca(OH)_2$

   Add 1,2,3,4,&5 # calcium hydroxide/ton ore and note the effect on perculation

B. Acid

1. H_2SO_4

   Add 1,2,3,4,&5 # H_2SO_4/ton ore and note effect on perculation.

Leaching

A. Basic

1. Pretreatment with lime
2. CaCN

B. Basic

1. Pretreatment with lime
2. NaCN

C. Acidic

1. Pretreatment with H_2SO_4 (1-5#/ton ore)
2. HTH

D. Acidic-Basic

1. Pretreatment with H_2SO_4
2. HTH

* After no more Au/Ag leaches

3. Neutralize with lime to 10.5
4. CaCN

E. Basic-Acidic

1,2 Lime & CaCN or NaCN

* After no more Au/Ag leaches

3,4 H_2SO_4 & HTH