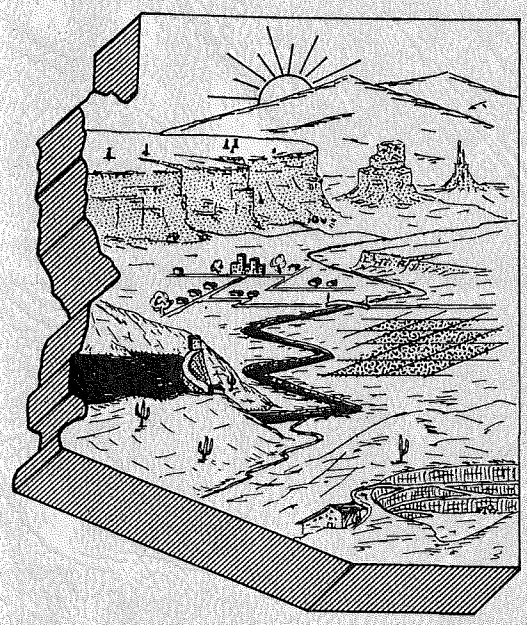
STATE OF ARIZONA
BUREAU OF GEOLOGY AND MINERAL TECHNOLOGY

Geological Survey Branch
Geothermal Group

Earth Science and Mineral Resources
in Arizona



STATE OF ARIZONA
BUREAU OF GEOLOGY
AND MINERAL TECHNOLOGY
OPEN-FILE REPORT
80-14

845 N. PARK AVENUE
TUCSON, ARIZONA
85719

RECOVERY OF METAL VALUES PRIOR TO RECLAMATION OF MINED AREAS IN THE SOUTHWEST

Prepared for

UNITED STATES DEPARTMENT OF INTERIOR

BUREAU OF MINES

by

DAVID D. RABB

State of Arizona
Bureau of Geology and Mineral Technology

University of Arizona
Tucson, Arizona 85721

Final Report
Contract No. J0295023
Recovery of Metal Values from Mine Dumps

June 30, 1980

STATE OF ARIZONA
BUREAU OF GEOLOGY
AND MINERAL TECHNOLOGY
OPEN-FILE REPORT

80-14

This report is preliminary and has not been edited or reviewed for conformity with Arizona Bureau of Geology and Mineral Technology standards. The observations contained herein are those of the author(s) and not necessarily endorsed by the Arizona Bureau of Geology and Mineral Technology.

REPORT DOCUMENTATION PAGE

1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle Recovery of Metal Values Prior to Reclamation of Mined Areas in the Southwest		5. Report Date June 30, 1980 6.
7. Author(s) David D. Rabb		8. Performing Organization Report No. B-80-861705
9. Performing Organization Name and Address State of Arizona Bureau of Geology and Mineral Technology, University of Arizona, Tucson, Arizona 85721		10. Project/Task/Work Unit No. 11. Contract or Grant No. J0295023
12. Sponsoring Organization Name and Address UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF MINES, SECTION OF CONTRACTS 2401 E St., NW, Washington, D.C. 20241		13. Type of Report Final Report 7/1/79 - 6/30/80 14.

15. Supplementary Notes

16. Abstract

A report on location, sampling, assays, mineral examination, amenability leach tests, and evaluation of certain mine dumps in Mohave County, Arizona. Extractions of greater than 30 percent of the gold and silver were achieved during simulated heap leaching of selected mine dump material. Consumption of reagents was relatively low and results suggest leaching of prepared heaps is technically viable and could be economically attractive.

17. Document Analysis A. Descriptors
BT: Ore Beneficiation
RT: Cyaniding
Extraction
Extractive Metallurgy
Hydrometallurgy
Solution Mining
Dump Leach

B. Identifiers/Open-Ended Terms
Mohave Co., Arizona
Mine Dump reclamation
Gold - Silver

18. Availability Statement
Release unlimited

19. U. S. Security Classif. of the Report	20. U. S. Security Classif. of This Page	21. No. of Pages	22. Price
Unclassified	Unclassified		

This Form may be reproduced.

FOREWARD

This report was prepared by the State of Arizona Bureau of Geology and Mineral Technology, University of Arizona, under U.S. Bureau of Mines Contract number J0295023. The contract was initiated under the Bureau of Mines Mineral Resources Technology Program. It was administered under the technical direction of the Salt Lake City Mining Research Center, Salt Lake City, Utah, with Monte B. Shirts acting as Technical Project Officer. L. J. Anderson, U.S. Bureau of Mines Section of Contracts, Building 20, Denver Federal Center, was the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as a part of this contract during the period July 1, 1979 to June 30, 1980. This report was submitted by the author on June 30, 1980.

No patentable features are included or to be found in this work.

TABLE OF CONTENTS

	Page
Report Documentation page	1
Foreword	2
Table of Contents	3
List of Illustrations	4
List of Tables	5
Acknowledgements	6
Introduction	7
Discussion and Results	8
Conclusions	19
Recommendations	20
Bibliography	21
APPENDIX 1	25
APPENDIX 2	32
APPENDIX 3	35

LIST OF ILLUSTRATIONS

Figure		Page
1	Mohave County, Arizona Map	10
2	Mine Location Map	11
	Supplement	12
	Photos of Typical Mine Dumps at the Pioneer Mine, Mohave County, Arizona	13
3	Time versus Extraction	16

LIST OF TABLES

Table		Page
1	Summary of Assays of Samples from Mohave Samples	9
2	Time versus Extraction	14
3	Cost Estimate for Typical Small Scale Waste Dump Gold Recovery	18

ACKNOWLEDGEMENTS

The cooperation and active friendly assistance of Walter C. Anderson, Mohave County Manager, and Roman Malach, County Historian, are gratefully acknowledged. Also, advice and guidance from Dr. Perry Durning, of Fischer-Watts Mining Company, Oatman, was useful and most appreciated. Others who aided in the accumulation of samples and data from CETA files, old mine records and personal experiences and knowledge were:

George Fass, Mohave County Community College

John H. Jett, Arizona Department of Mineral Resources

Pat Patterson, Chloride, Arizona

Vernon B. Dale, P.E., Dragoon, Arizona

George McDevitt, Small Mine Owners Association, Kingman

INTRODUCTION

In mid-1979, the Bureau of Geology and Mineral Technology, State of Arizona, was awarded a research contract by the U.S. Bureau of Mines to study the possibility of recovering precious metals from Mohave County mine dumps. The work was essentially a continuation of the Federal Civilian Employment Training Agency (CETA)-funded Mine Project conducted by Mohave County and the Arizona Department of Mineral Resources in 1976-77. See Appendix 1.

The CETA study was centered around the Cerbat area north of Kingman and work was performed in this Laboratory on lead-zinc ores from that area. See Appendix 1 for a report on the results of flotation tests using material from one of the larger dumps. No sampling or leaching tests were performed on mine dumps in the southern portion of the county, predominantly an area of former gold and silver producers.

One large mine dump north of Kingman that was not sampled in the CETA Project, the Golconda, was included in this sampling program after permission to enter had been granted. See Samples 11-15 inclusive, Table 1.

Since cyanide leaching of precious metal from mine dump material has proven historically to be relatively safe and economically successful in many locations throughout the Southwest, the consensus was that Mohave County dump materials in the Oatman-Goldroads area should be investigated.

The Tom Reed tailings at Oatman were studied briefly but values as listed in Appendix 2 were considered to be too low and the material too refractory in nature to warrant further investigation.

DISCUSSION AND RESULTS

A total of thirty-nine samples were taken from thirteen mine dumps and mill tailings dumps which were (1) fairly accessible, (2) of reasonable tonnage and (3) by reason of history or recommendation, deemed worthy of consideration. Results of fire assays of prepared samples are listed in Table 1. The bulk of the samples appear too low in value to be attractive for any further consideration. See Figures 1 and 2 for locations.

The relatively high values in the first set of samples from the Pioneer dumps (Samples 5-8 inclusive) and the tonnages involved, were considered significant enough to warrant mineralogical examination plus microscopic and spectroscopic analyses of concentrates from panning tests. Traces of fine free gold were found in three of the four samples but there were no other significant mineral values. The material was principally rhyolite wall rock with some weathered red brown quartz vein material including some small occurrences of a crystalline calcite. A resampling of the Pioneer dumps resulted in substantially lower showings (Table 1, Samples 22-32) than the previous set, Samples 5-8. However, considering the size and location of these dumps, an average value on the order of $15.00 per ton is still viable feed-ore to a heap leach operation.

In a simulated heap-leach using a carefully bedded 22-inch column of composited ore from Pioneer Samples 5, 6, 7 and 8, seven kilograms of ore, crushed to minus one-quarter inch, were leached by a slow-drip downward percolation using four liters of sodium cyanide solution. The leach solution was first mixed with 2 pounds of lime per ton of ore and then sodium cyanide was added to give 0.1 pounds of free cyanide per ton of solution. The flowrate was approximately 5 cc per square centimeter per hour. The pH of the leach liquor varied from 12.0 at the start of the test to 10.5 after 10 days. No additional lime was added. Additional sodium cyanide was added as needed in half-pound-per-ton-of-ore increments to maintain a free cyanide reading in the pregnant OFF-solution of approximately 0.1 pounds of cyanide per ton of solution (as determined by silver nitrate titration).

As stated above, lime consumption was 2 pounds per ton of ore and the total sodium cyanide required to maintain the free cyanide strength in the solution amounted to 2.5 pounds per ton after ten days retention time.

As shown in Table 2, the recovery of gold, as determined by assays of solution aliquots, was 19 percent after 48 hours and 26 percent after 10 days. The corresponding silver extraction was 16 percent in 48 hours and 28 percent after 10 days. Damage to the leach column after 22 days prevented further solution assays but an assay of the washed leached tails indicated slightly over 30 percent of both metals had been dissolved in that time. An additional 1 pound of lime and one-half pound of sodium cyanide were added to maintain a pH of 10 to 11 and the proper free cyanide concentration in the pregnant OFF-solution during the period from 10 to 22 days of leaching.

TABLE 1. SUMMARY OF ASSAYS OF SAMPLES FROM MOHAVE SAMPLES

Sample No.	Location	Type of Sample*	Assay Oz. per ton Gold	Silver	Remarks	Tonnage	T-N	R-W	Location Section	District
1	Katherine	Tails	0.040	2.00	Red-Tan, taken from cuts.					
2	Katherine	Tails	Trace	1.40	White, 2 feet deep.					
3	Katherine	Tails	0.040	1.80	White, top and slopes.	Large	21	21	5	San Francisco
4	Katherine	Tails	0.020	1.60	White, mill tailings dumps.					
5	Pioneer	Dump	0.180	2.00	Light tan Taken from 10 foot cuts					
6	Pioneer	Dump	0.040	2.20	Yellow tan 2 feet down from 4					
7	Pioneer	Dump	0.300	3.20	Brown scattered mine dumps.	Large	19	20	21	San Francisco
8	Pioneer	Dump	0.280	3.15	Dark brown OXIDIZED ORE.					
9	Mossback	Dump	0.020	0.85	Grey tan Grab samples,	Small	20	20	28	San Francisco
10	Mossback	Tails	0.060	1.20	Tan near surface.	V.Small				
11	Golconda	Dump	0.050	2.15						
12	Golconda	Dump	0.010	1.60	Grey, slightly oxidized, lead-zinc					
13	Golconda	Dump	0.060	2.15	sulphide ores, not leaching ore.	Large	23	18	12	Cerbat
14	Golconda	Dump	0.040	1.20						
15	Golconda	Dump	0.040	2.20						
16	Goldroads	Tails	0.040	1.10	White; eroded, scattered piles.	Large	19	20	11	San Francisco
17	United Eastern	Tails	0.060	1.75	White	Large	19	20	14	San Francisco
18	Chemehuevi	Placer	Trace	2.20	Extensive placer terrace.					
19	Chemehuevi	Placer	Trace	1.20	Extensive placer terrace.	V.Large	13	20	--	Chemehuevi
20	McCracken	Tails	0.056	Nil	Mill dumps at Signal Mill,					
21	McCracken	Tails	0.008	Nil	samples by R. Malach.	Small	13	15	25	Owens
22	Pioneer	Dump	Trace	0.15						
23	Pioneer	Dump	0.066	<0.05						
24	Pioneer	Dump	0.010	<0.05						
25	Pioneer	Dump	0.006	0.05	Resampling of Pioneer area 2 feet					
26	Pioneer	Dump	0.006	0.40	deep cuts in tops and slopes of					
27	Pioneer	Dump	0.046	0.40	mine dumps, red-brown oxidized	Large	19	20	21	San Francisco
28	Pioneer	Dump	0.048	0.30	quartz and calcite vein					
29	Pioneer	Dump	0.022	0.50	material.					
30	Pioneer	Dump	0.038	<0.05						
31	Pioneer	Dump	0.152	0.45						
32	Pioneer	Dump	0.010	0.10						
33	White Chief	Dump	0.040	0.50	Slope					
34	White Chief	Dump	0.304	0.40	Top Ore pile stacked					
35	White Chief	Dump	0.328	0.15	Reverse Slope NE of shaft collar.	V.Small	19	20	27	San Francisco
36	White Chief	Dump	0.228	0.70	Selected grab					
37	United Eastern	Dump	0.110	0.05	Dump slope sample at Horseshoe curve.	Medium	19	20	14	San Francisco
38	Shepard	Dump	0.024	0.05	Special "OXIDE" sample by C. T. Shepard..	Small	22	17	23	San Francisco
39	Arabian	Ore Pile	0.016	6.20	Random grab.	Medium	21	20	26	Union Pass

*Dump (mine dumps)
Tails (mill tailings)
Placer (placer deposits)

Large (estimated recoverable tonnage - more than 50,000 tons)
Medium (estimated recoverable tonnage - 5,000 to 50,000 tons) from all material at one site.
Small (estimated recoverable tonnage - less than 5,000 tons)

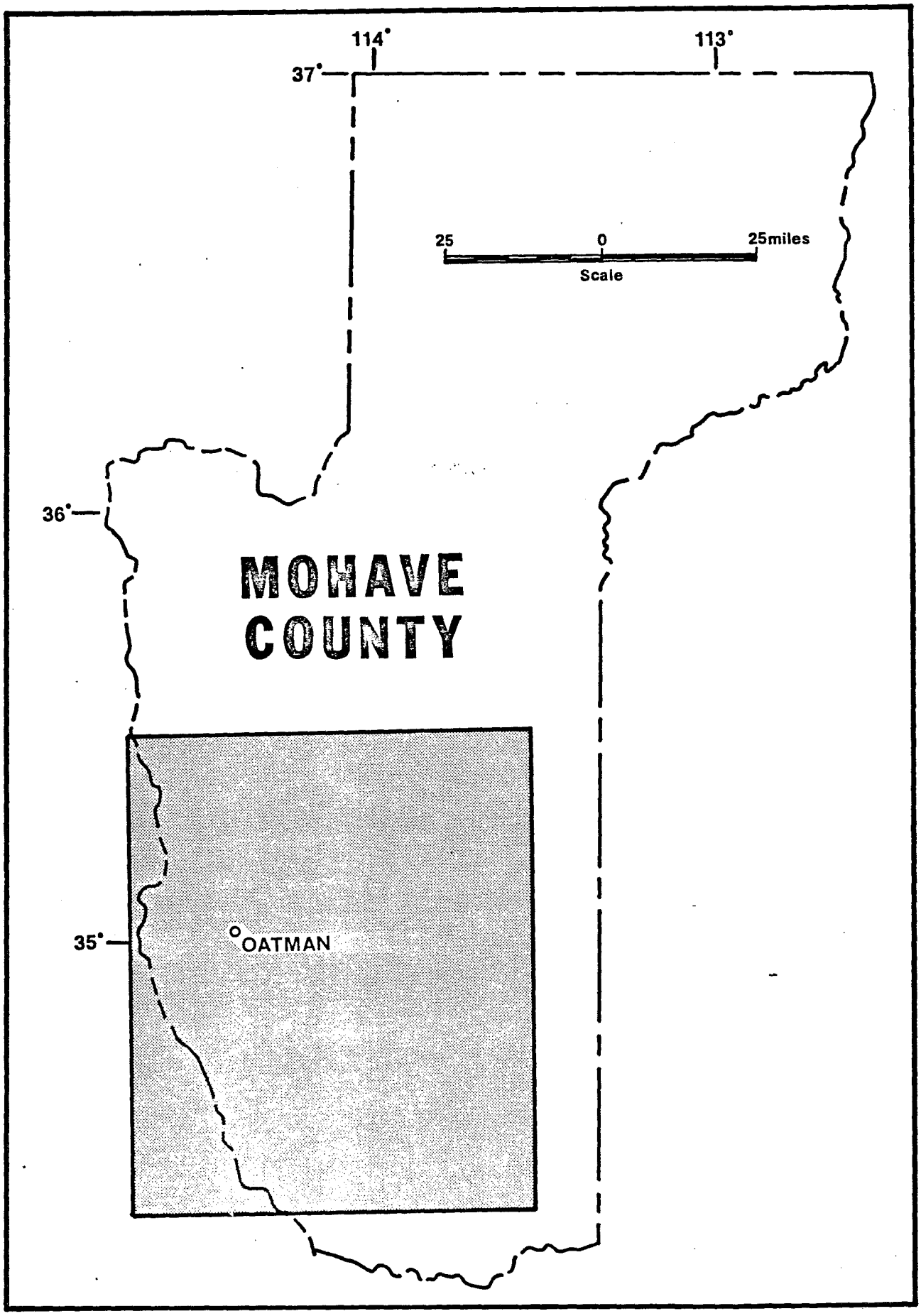


Figure 1, Mohave County, Arizona

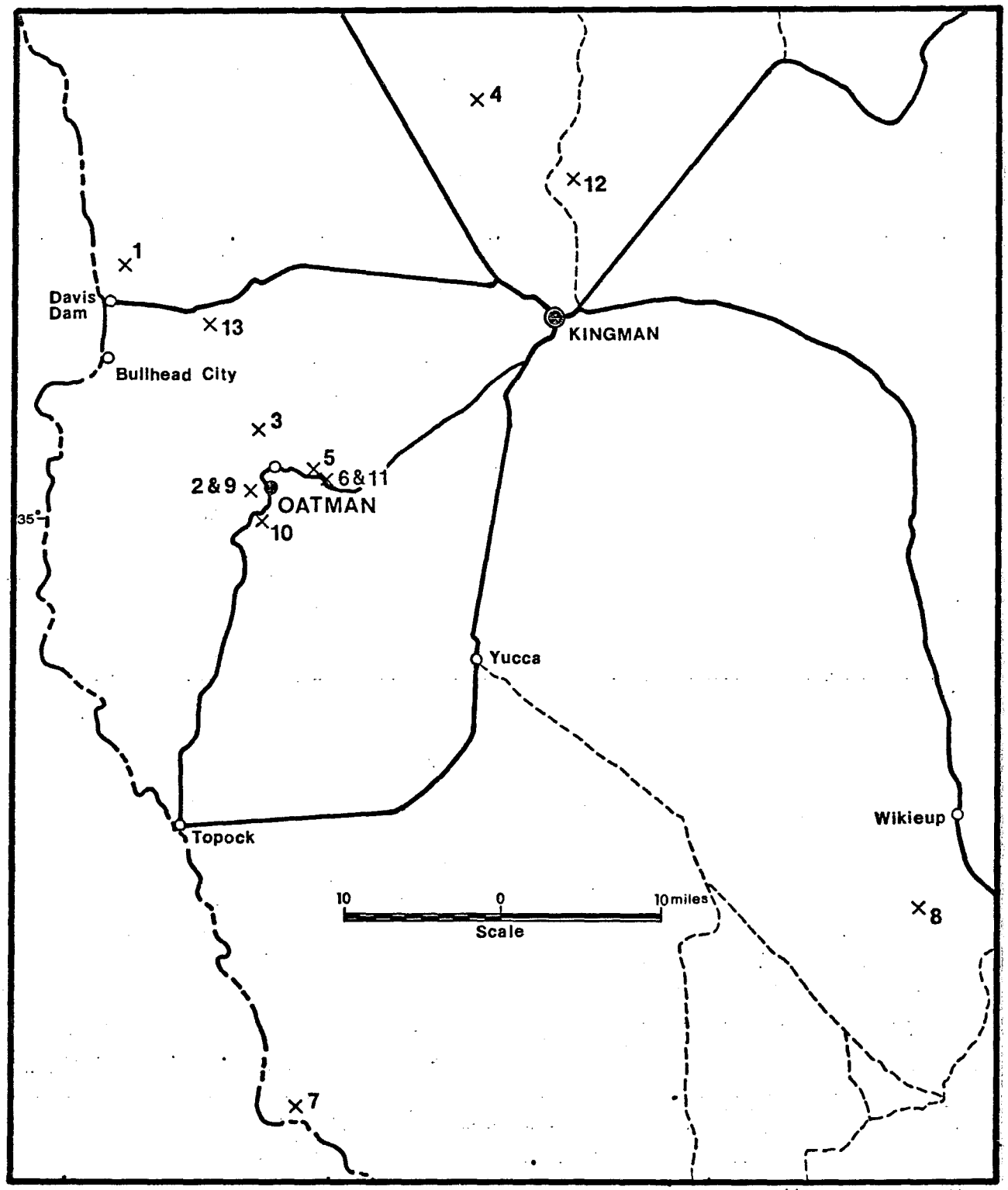


Figure 2, Mine Location

Figure 2 Supplement

Mine Location, see Figure 2

Number	Mine
1	Katherine
2	Pioneer (See Figures 2A and 2B)
3	Mossback
4	Golconda
5	Goldroads
6	United Eastern
7	Chemehuavi
8	McCracken
9	Pioneer
10	White Chief
11	United Eastern
12	Shepard
13	Arabian

Figure 2A

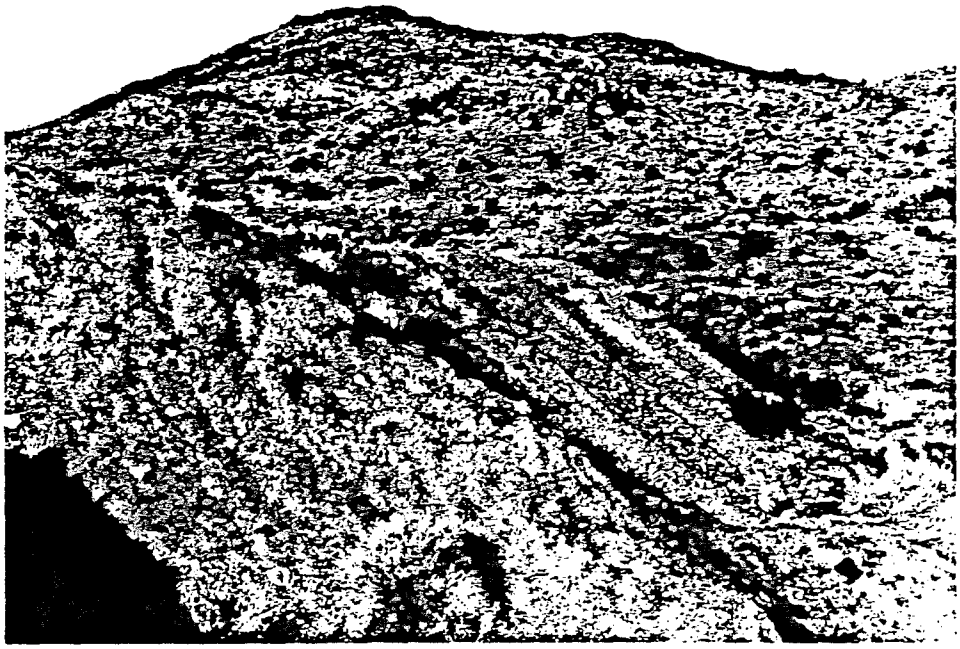


Figure 2B

Figure 2 - Photos of Typical Mine Dumps at the Pioneer Mine Mohave County, Arizona.

TABLE 2

TIME VERSUS EXTRACTION

	Elapsed Leach Time, Hours	Extraction, percent Gold	Silver
Leaching Test I PIONEER	48	19	16
	240	26	28
	528	30	30
Leaching Test II WHITE CHIEF	7	1.3	4.4
	22	31.9	16.7
	73	42.1	21.2
	96	52.7	25.9
	120	53.9	32.2
	144	52.7	32.2
	171	55.5	31.5

		Ounces per ton Gold	Silver
PIONEER	HEADS	0.205	2.66
	LEACHED TAILS	0.142	1.85
	EXTRACTION, %	30.7	30.5
WHITE CHIEF	HEADS	0.225	0.45
	LEACHED TAILS	0.123	0.16
	EXTRACTION, %	54.5	35.6

There was little or no apparent change in permeability of the bed during the 22 days. There was no noticeable degradation of the ore, nor was there any plugging or channelling. The first OFF solutions were slightly turbid but clarified after repeated recycling. The solution volume in the leach circuit was maintained at a constant volume to make up for evaporation and sample withdrawal.

If the leaching cycle could have continued uninterrupted, it is estimated that the projected extraction of the gold could approach 40 percent in 30 to 60 days.

Common operational practice is to add another lift of fresh ore to the heap in order to keep the strength of the pregnant OFF solution high enough to warrant pumping. In this manner additional extraction can, in many cases, be achieved because undissolved values in the older or bottom layers slowly continue to go into solution.

A second leaching test was carried out using ore composited from the four White Chief samples. The same 22-inch column and one-quarter inch feed was used with slow film percolation. An initial addition of one half pound of lime per ton gave a pH of 11.5. Sodium cyanide required to maintain about 0.5 pounds of free cyanide per ton of pregnant OFF solution amounted to 0.6 pounds per ton of ore. There was no noticeable change in permeability in the leach column after seven days leaching.

The time-versus-extraction curve is presented in Figure 3. Results of assays of the final washed tails agreed roughly with the overall extraction indicated by assays of the solution; i.e., about 55 percent for gold, 35 for silver for a leaching time of seven days. It is evident, however, that the extraction curves in Figure 3 flatten after only 5 days leach time. Also see Table 2.

The cost to install a simple leach pad, emplace a heap of leachable ore and to operate a cyanide heap leach system depends upon a number of factors such as access, utilities, terrain, flood control, height of lift or lifts, solution distribution system and other operational factors. However, based on experiences at Tombstone, Congress, Arivaca, and other sites in Southwestern Arizona the average expenses of such operations are estimated as follows:

1. Site preparation:

   devegetation
   sloping
   drain preparation
   flood control - $500.00 to $2,000.00 per acre

2. Pad Construction

   (A multi-layered, rolled mill-tailings slime-fraction is recommended) - $1,000.00 to $4,000.00 per acre

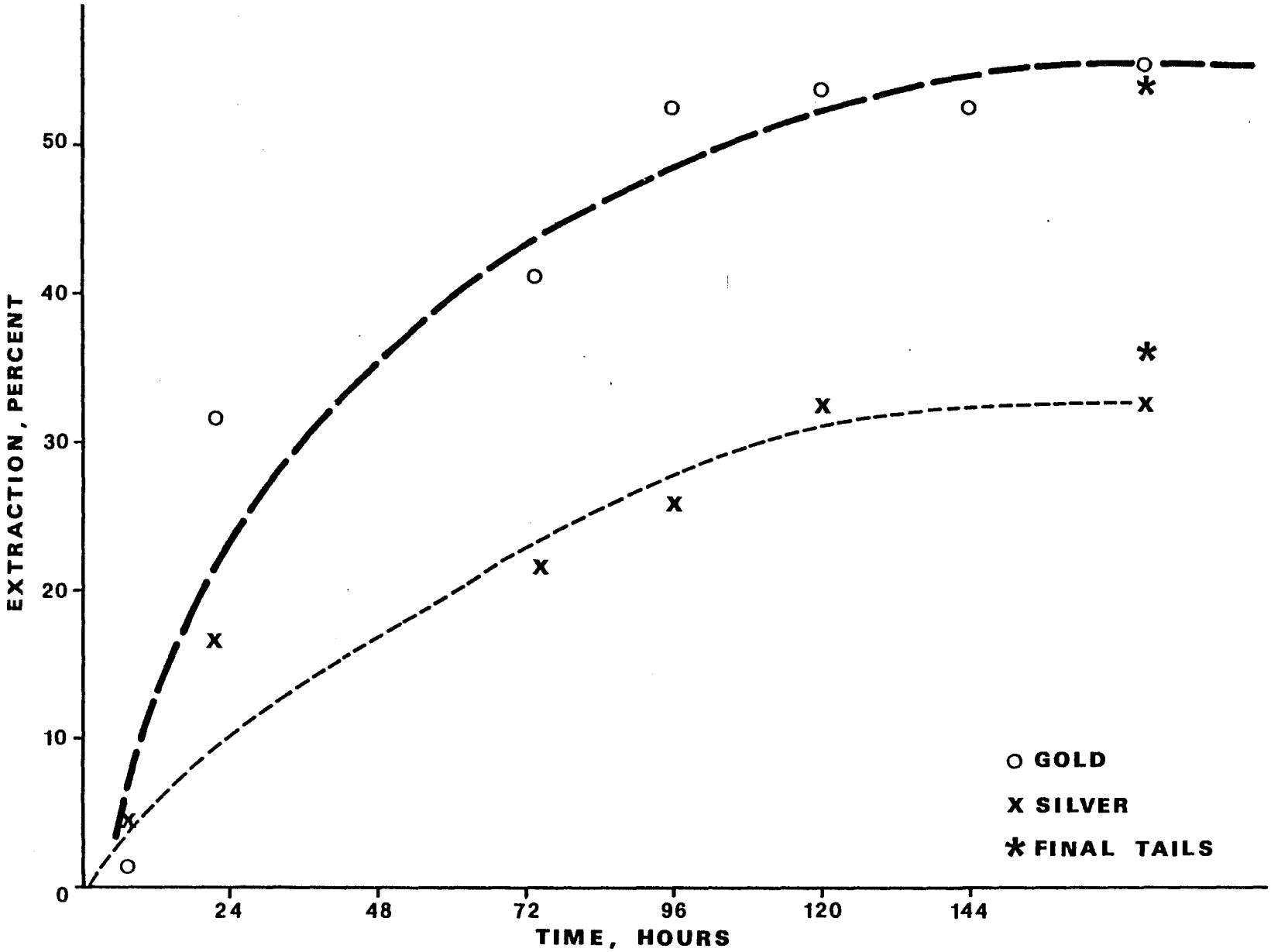


Figure 3, Time Versus Extraction
White Chief Composite Dump Sample

3. Ore emplacement

(8 to 10 foot lift, with no truck runs on dump surface) (pre-wetting and some pelletizing during emplacement may be advisable)

- $2.00 to $8.00 per ton

4. Pregnant OFF-solution recovery system

(plastic lined ditches).

- $2,000.00 to $6,000.00

5. Solution distribution system

- $2,200.00 per acre

The total investment as well as operating cost for such an installation can amount to considerably less than the cost of a comparable counter-current-decantation (CCD) cyanide plant by a factor of as much as eight or ten. Metal recoveries are lower (and slower) but net return on investment is better.

For example, based on current field experience in the Southwest, the capital costs for leaching a hypothetical dump of 20,000 tons of gold-bearing waste can be roughly estimated as shown in Table 3. Note that land values are not taken into account.

Also, based on current operations, the operating cost might average $1,000 per day. In 6 months this equals $9.35 per ton of ore. See Table 3.

Next, let us assume that in 6 months a 40 percent extraction is achieved. If the ore contains 0.1 ounces of gold per ton and if the price of gold is $650 per ounce (7/7/80 - $663.50 per ounce, Handy & Harmon, NY) the market value of the recovered gold would be on the order of $26 per ton. Therefore, as shown in Table 3, the heap leach, at an estimated cost per ton of $18.61, could be deemed profitable. Also, based on the 40 percent recovery from 0.1 ounce per ton (OPT) ore, the cost per ounce of gold recovered is $252.00. See Table 3.

On the other hand, the cost of a 100-ton per day CCD plant to handle 20,000 tons in six months is estimated to be on the order of $400,000 to $500,000. Plus, operating costs would be almost double for the CCD plant over the heap leach.

A conventional CCD plant can effect a higher recovery of available gold from a particular ore in a shorter period of time than can be obtained from heap leaching. However, a heap leach of the same ore can usually, given time, approach the CCD extraction figure and frequently can do so more economically. Reasons: lower capital outlay, lower maintenance and operating costs in both dollars and energy.

The prime consideration must be the amenability of the ore to heap leaching. The amount of recoverable gold, not the total gold in the ore is the key. In any case a pilot heap leach test is essential before setting up a full scale operation.

TABLE 3

COST ESTIMATE FOR TYPICAL
SMALL SCALE WASTE DUMP GOLD RECOVERY

Basis: 20,000 tons gold-bearing waste at 0.1 ounces of gold per ton at 40% extraction, in 6 mos.

	Cost	Cost per Ton, $	Cost per Oz. Recovered, $
Capital Cost			
Fixed Capital			
Site & Pad Preparation	6,000		
Solution Handling	10,000		
Precipitation	22,000		
Contractor's Fee - Haulage	100,000	5.00	
Total Fixed	138,000		
Contingency @ 10% fixed	13,800		
Insurance @ 1% fixed	1,400		
Total Installed Capital	153,200		
Working Capital @ 10% Installed Capital	15,300		
Total Capital	168,500		
Interest @ 15% Total Capital Requirements	25,275		
Total Fixed Investment	193,775	9.69	237.50
Operating Cost			
Reagents	25,000		
Utilities	50,000		
Labor, 7280 Man-hrs. @ $13.00 including Burden	95,000		
Total Direct Cost	170,000		
Contingency @ 10% Direct	17,000		
Total Operating	187,000		
Total Cost	380,775	19.04	466.50
Margin			
Value of Gold @ 40% Recovery Assuming $650/troy ounce	520,000	26.00	650.00
Margin	139,225	6.86	174.03

CONCLUSIONS

A survey and sampling of mine dumps in southern Mohave County shows that there are significant tonnages of ore which contain gold and silver values sufficiently high to be economically attractive.

The results of cyanide leaching of two different ores from the Oatman area indicate that an appreciable percentage of the precious metal values can be extracted in a reasonable time; i.e., on the order of 30 percent in 10 days.

Simulated heap-leach tests of these ores showed:

1. low lime and cyanide consumption

2. permeabilities remained constant with no degradation of leached material

3. and, considering the less expensive preparation and processing, an overall extraction could be economically attractive.

Further, a demonstration of the practicality and technique of heap leaching could be a real benefit to the small mine owners and operators in the area.

RECOMMENDATIONS

A pilot test on a small (say 10 or 50 tons) heap of selected dump material from a Mohave County mine is a logical and recommended next consideration.

After a search for and preparation of a suitable site, it is recommended that a study be accomplished to establish costs, define problems, and clarify the feasibility of treating certain selected dumps.

A cooperative effort by county (for equipment use), mine owners (for sites, water and ore) and State agencies has been proposed and tentatively agreed to by those concerned. Federal participation is the key to bring it all together.

BIBLIOGRAPHY

1. Arizona Mining Journal. History of Tom Reed Mine is story of success after failure. V. 5, No. 10, 1921, p. 24

2. Arizona Mining Journal. United Eastern Company pushing development work. V. 5, No. 10, 1921, p. 22

3. Bagg, J.S. Professional report on various mining properties in the Cerbat range, Mohave County, Arizona. Arizona Bureau of Geology and Mineral Technology files. 1954

4. Bancroft, H. Geology of the Gold Road district. (near Kingman, AZ.) Mining Science Press, V. 111, 1915, p. 21

5. Burgess, J.A. United Eastern mine, Oatman, Ariz. Engineering Mining Journal. V. 102, 1916, pp. 232-233.

6. Burgess, J.A. United Eastern Mining Company, Ariz. Mining Journal. V. 4, 1920, pp. 41-43.

7. Dale, V. and Rudy, S. Custom Mill Project and Mohave County Mining Project Report. Professional report, 1977.

8. DeWolf, W.P. Katherine district. Activity opens promising properties. Ariz. Mining Journal., V. 5, No. 12, 1921, p. 22

9. Dinsmore, C.A. History and development of the Gold Road Mine. Mining Engineering World, V. 35, 1911, p. 1275-76

10. Doman, R.S. The lure of Arizona gold was inspiration for Oatman, Ariz. Mining Journal. V. 6, No. 14, 1922, pp. 3-4

11. Elsing, M.J. and R.E.S. Heineman. Ariz. Metal Production. Univ. of Ariz., Ariz. Bureau of Mines Bulletin 140, 1936, p. 112

12. Householder, E.R. Geology of Mohave County, Arizona; Ariz. Bureau of Geology and Mineral Technology files, 1929

13. Householder, E.R. Report on Victoria Gold Mines, Oatman gold district, Arizona. Professional report, 1948

14. Jarrad, L.D. An appraisal of the Tom Reed tailings, Oatman, Arizona. Professional report, 1959

15. Johnson, C.H. Mining and Milling methods at the Big Jim mine. Oatman, Ariz., USBM, I.C. 6824, 1935, p. 12

16. Lausen, C. Geology and ore deposits of the Oatman and Katherine districts, Ariz. Univ. of Ariz., Ariz. Bureau of Mines Bulletin 131, maps, 1931, p. 126

17. Lausen, C. Gold veins of the Oatman and Katherine districts, Ariz. Univ. of Ariz. PhD Thesis , maps, 1931, p. 155

18. Lausen, C. The Oatman and Katherine districts, Ariz., Ore deposits as related to structural features, Princeton Univ. Press, 1942, pp. 226-229

19. Martin, A.H. San Franciso district, Ariz., Mining World, V. 31, 1909, p. 368

20. Mining Journal. Annual report issued by Tom Reed Gold Mines Company. V. 21, No. 3, 1937, p. 37

21. Nolan, T.B. Epithermal precious metal deposits. Ore deposits of the Western States, AIME Lindgren Volume, 1933, p. 623-30

22. O'Brien, J.F. Diamond drilling operations increasing in Oatman district. Ariz. Mining Journal., V. 5 No. 19, 1922, pp. 20-21

23. O'Brien, J.F. Gold properties at Oatman preparing for development. Ariz. Mining Journal., V. 5, No. 20, 1922, p. 25

24. Palmer, L.A. The Oatman District, Ariz. Engineering Mining Journal., V. 101, 1916, pp. 895-900; Mining Science Press, V. 113, 1916, pp. 193-196

25. Probert, F.H. Oatman, Ariz. (Geol. and Mineralization). Mining Science Press, V. 112, 1916, pp. 17 - 20

26. Ransome, F.L. Geology of the Oatman Gold Road district. U.S. Geological Survey Bulletin, No. 743, 1923

27. Rickard, T.A. Tom Reed Gold Mine vs. United Eastern Company. Mining Science Press, V. 122, 1921, pp. 677-681

28. Ritter, E.A. Oatman and the Tom Reed-Gold Road mining district, Ariz. Mining World, V. 44, 1916, p. 645-648

29. Schrader, F.C. Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona. U.S. Geological Survey Bulletin, No. 297, 1909

30. Schoder, J. and Allsman, P.T. Mining and milling methods and costs at the Tennessee-Schuylkill Corp. mine. Bureau of Mines I.C. 7077, June, 1939

31. Schrader, F.C. Geology and Ore deposits of Mohave Co., Ariz. (with discussion by J.D. Speer, J.B. Platts, and J.C. Anderson). AIME Bulletin 119, 1957, p. 1935-1957, maps; Bulletin 123, 1917, p. 379-384; Bulletin 124, 1917, p. 456-460; Trans., V. 56, 1917, maps, p. 195-236

32. Schrader, F.C. The Ore deposits of Mohave Co., Ariz. Mining Science Press, V. 113, No. 21, 1916, p. 733-37

33. Schwartz, G.M. The host minerals of native gold. Econ. Geol., V. 39, No. 6, 1944, pp. 371-411, illus.

34. Scott, W.Z. Present development of the Oatman district, Ariz. Mining Engineering World, V. 44, 1916, pp. 1033-1038

35. Shaw, E.A. United American Mining Company. Ariz. Mining Journal., V. 4, No. 3, 1920, pp. 21

36. Sperr, J.D. The Tom Reed Gold Mines Company, Ariz. Mining Engineering World, B. 45, 1916, p. 1-5

37. Spillman, C.F. Tom Reed Gold Mines Company, Ariz. Mining Engineering World V. 45, 1916, p. 1073-74

38. Spillman, C. Big Jim reopens. Mining Journal., V. 14, No. 20, 1931, p. 26-28

39. Tovote, W.L. Gold Road, die dedeutendste Goldgrube Arizona. Oesterreichische Zeitschrigt fur Berg-und Hutterwesen, V. 54, 1906, Wien, pp. 549-550

40. Willis, C.F. The Union Pass boom centers around Catherine Mine., Ariz. Mining Journal., V. 4, No. 12, 1921, p. 50

41. Wiseman, P. United Eastern Report gives future plans. Ariz. Mining Journal., V. 8, No. 6, 1924, pp. 9, 23-24

42. Wolle, M. Oatman: Arizona's 20th century gold camp. Mining World, V. 18, No. 7, 1959, p. 68

APPENDICES

1 Copy of CETA Memorandum from S. Rudy to V. Dale, 1976, pp. 25-31

2 Tom Reed Tailings Assays, L. Jarrard, 1959, pp. 32-34

3 Copy of CETA Report on "The Feasibility of a Custom/Toll Mill, in Mohave County", 1977. Resource Base, Measured and Sampled Reserves in the Cerbats.

APPENDIX 1

Copy of Memorandum to V. Dale from Sam Rudy on results of laboratory flotation tests on a lead-zinc Mohave County tailings: CETA Mine Study, 1976

State of Arizona
Bureau of Geology and Mineral Technology

Mineral Technology Branch
University of Arizona
Tucson, Arizona 85721
(602) 626-1943

September 20, 1976

MEMORANDUM

To: Mr. Vernon Dale
Arizona Department of Mineral Resources

From: Mr. Sam Rudy S.R.

At the request of Mr. Vernon Dale, Project Engineer for the CETA mining project, the Arizona Bureau of Mines was asked to participate in the evaluation of the Tennessee-Schuylkill tailings. The Bureau was asked to conduct laboratory flotation tests and determine the response of this material to standard flotation procedures for the recovery of zinc, lead, silver and gold.

Two samples were tested in the Arizona Bureau of Mines Laboratory. Sample one was delivered to the laboratory by Mr. Dale in late July. Sample two was given to representatives of the Bureau by Mr. Dale at the Tennessee-Schuylkill tailing site in mid-August. Both samples were obtained by making a vertical auger cut from the top of the dump to the original ground surface. Sample one was cut from near the center of the dump and sample two was cut between the center and the north periphery of the dump. The exact location and identification of the samples were recorded by Mr. Dale. Prior to testing, both samples were dried, weighted, and split into representative 1000 gram test packets. Representative fractions were also split out for chemical analysis, mineralogical examination and screen analysis.

Flotation tests were conducted in a procedure consistant with standard froth flotation practice for the recovery of sphalerite from pyritic ores. In general, the procedure was as follows. One thousand grams of tailing was attrited at 70% solids with tap water for five minites in a Denver D-1 laboratory flotation cell. The pulp was diluted to 35% solids and suitable additions of the indicated reagents were added. The diluted pulp was conditioned for five minutes, air was introduced and froth was drawn for 12 minutes. Rougher froth was cleaned for 6 minutes and then recleaned for 4 minutes. Products from each test were filtered, dried, weighed and assayed. Metallurgical results were tabulated for each test and they are presented on the attached sheets.

A Division of the
University of Arizona

The first laboratory considerations in the development work described in this memo were the determination of metal content, mineralogical associations, and size distribution of contained metal values. Table I gives the assay results obtained for the two tailing samples tested. Also listed, Item 3 is an average analysis from operating data at the Tennessee-Schuylkill mill for September, 1938.

Table I

Metal Content of Tennessee-Schuylkill Tails

Identification	Assays %Zn	%Pb	%Cu	OPT Ag	OPT Au
Sample 1	0.90	0.15	.02	0.15	0.005
Sample 2	1.56	0.15	.02	0.33	0.015
September, 1938	0.75	0.10	---	0.16	0.010

Examination of representative portions of Tennessee-Schuylkill tailings under the binocular microscope indicated most of the zinc was present as marmatite. Minor amounts of galena and arsenopyrite were also present with trace quantities of chalcopyrite. Pyrite was abundant and is reported to occur in two distinct forms; as well-defined, well-crystallized cubes with no gold, and as somewhat massive and fine-grained material containing from 0.3 to 15.0 ounces of gold per ton. The distinction between these two types was not obvious in the tailings samples examined. The primary gangue material was quartz.

Table II illustrates the distribution of zinc throughout the tailing and gives a size distribution of one of the tailing samples tested.

Table II

Distribution of Zinc in Sample One

Mesh Size	Wt. %	% Zinc	% Distribution
+48	2.5	.30	0.8
-48+65	6.4	.31	2.1
-65+100	11.0	.54	6.4
-100+200	16.0	.82	18.0
-200+325	12.3	.72	9.5
-325	51.8	1.14	63.2
	100.0	.93	100.0

Table II shows that over 63 percent of the zinc contained is finer than 325 mesh indicating that most of the zinc losses from the original mill treatment were associated with the slimes fraction. Microscopic examination of the tailings as well as the results of chemical analyses indicated that sufficient galena was not present to warrant a separate recovery circuit. Flotation experiments were thus directed at the recovery of marmatite and associated gold and silver values.

Zinc minerals are not usually ameanable to flotation in their natural state. Flotation will not occur unless these minerals have been activated by one or more heavy metal salts, usually copper sulfate. Preliminary exploratory flotation tests indicated that some of the marmatite and a good part of the pyrite, especially in tailings sample two, were activated because of their history. Lime was used to adjust the pH to between 9 and 9.5 in rougher flotation, and between 11.2 and 11.5 in cleaning and recleaning to reject as much pyrite as possible. Exploratory testing also indicated that the use of a strong collector such as potassium amyl xanthate or dodecyl mercaptan significantly lowered concentrate grade by floating barren pyrite. Consequently, data were generated for the two tailings samples tested using a much more selective collector combination consisting of potassium ethyl xanthate and sodium aerofloat. Methyl iso-butyl carbanol was used as the frothing agent.

Table III shows comparative metallurgical data generated using the above described reagents and procedure. Detailed description of the flotation tests are presented on the attached sheets.

Table III

Metallurgical Summary for Tennessee-Schuylkill Tailing Flotation Tests

Sample No.	Concentration Ratio	Grade Zinc Recleaner Con.			% Recovery into Recleaner Con.		
		%Zn	OPT Au	OPT Ag	Zn	Au	Ag
1	98	34.6	.122	3.20	37.0	18.1	10.9
2	267	29.1	----	----	6.9	----	----

Sample one responded much better than did sample two. However, a salable product could not be generated from either under the conditions tested. Recleaner concentrate contained substantial quantities of pyrite both free and intimately associated with marmatite. In the case of sample one, it is possible that further treatment including regrinding and reflotation could yield a higher grade concentrate with a corresponding reduction in overall zinc recovery. In the case of sample two, it does not appear that further treatment would be economically justified under any circumstance.

Based on the results of these preliminary flotation tests, it appears that a range of from 7 to 37% of the zinc contained in the Tennessee-Schuylkill tailings can be recovered in a concentrate containing from 29 to 35% zinc

by standard flotation treatment. It also appears that about 20% of the gold and 10% of the silver will report in the zinc concentrate. Recovery of zinc, silver and gold from these tailings does not appear to be economically attractive at this point.

cc: W.H. Dresher, Director
D.D. Rabb
J. Jett, Department of Mineral Resources

UNIVERSITY OF ARIZONA

ARIZONA BUREAU OF MINES

ORE TESTING SERVICE

Ore No. 1 (Sample One) Test No. Tennessee-Schuylkill Tails

Conditions and Reagents

Point of Addition	Conditions			Reagents Pounds Per Ton									
	Time Mins.	% Solids	pH	$CuSO_4$	$Ca(OH)_2$	Z-3	NaAF	MIBC					
Attrition	5	70	6.2	-	-	-	-	-					
Condition	5	35	9.0	1.0	4.0	.05	.10	.05					
Rougher Flotation	12	-	9.0	-	-	-	-	-					
Cleaner Flotation	6	-	11.2	-	2.0	-	-	-					
Recleaner Flotation	4	-	11.5	-	2.0	-	-	-					

Remarks: Pulp slimy and viscous. Some pyrite present in rougher froth with marmatite. Good froth. Some marmatite fell out in cleaning. Some pyrite present in recleaner concentrate. May need to regrind recleaner conc. and refloat.

Metallurgical Products

Product	Tons in 100 Tons Feed	Assays						% of Total					
		Zn	Au	Ag				Zn	Au	Ag			
Re. Cl. Con.	1.02	34.60	.122	3.20				37.0	18.1	10.9			
Re. Cl. Tail	1.17	9.95	.088	2.09				12.2	15.0	8.2			
Cl. Tail	5.62	.75	.016	.38				4.4	13.1	7.1			
Ro. Tail	92.19	.48	.004	.24				46.4	53.8	73.8			
Calc. Hd.		.95	.007	.30				100	100	100			

Remarks: Sample one responded much better than did sample two.

METALLURGICAL RESULTS OBTAINED ABOVE SHOULD BE CONSIDERED AS ONLY APPLICABLE TO MATERIAL CONFORMING TO THE CHARACTER OF THE SAMPLE UPON WHICH THE TESTS WERE MADE.

UNIVERSITY OF ARIZONA

ARIZONA BUREAU OF MINES

ORE TESTING SERVICE

Ore No.....2.....(Sample Two) Test No.Tennessee-Schuylkill Tails

Conditions and Reagents

Point of Addition	Conditions			Reagents Pounds Per Ton									
	Time Mins.	% Solids	pH	$CuSo_4$	$Ca(OH)_2$	Z-3	NaAF	MIBC					
Attrition	5	70	5.3	-	-	-	-	-					
Condition	5	35	9.3	1.0	7.0	.05	.10	.05					
Rougher Flotation	12	-	-	-	-	-	-	-					
Cleaner Flotation	6	-	11.5	-	2.0	-	-	-					
Recleaner Flotation	4	-	11.5	-	2.0	-	-	-					

Remarks: Pulp slimy and viscous. Large quantity of pyrite present in rougher froth. Miner quantity of marmatite present. More lime required than in test 1 to obtain proper pH. Much pyrite in cleaner and recleaner concentrate.

Metallurgical Products

Product	Tons in 100 Tons Feed	Assays						% of Total					
		Zn						Zn					
Re. Cl. Con.	0.37	29.10						6.9					
Re. Cl. Tail	3.08	5.20						10.2					
Cl. Tail	8.51	2.13						11.6					
Ro. Tail	88.03	1.27						71.3					
Calc. Hd.		1.57											

Remarks: Very poor response to flotation. Zinc appears to be associated with pyrite. Try cyanide to assist in pyrite depression.

METALLURGICAL RESULTS OBTAINED ABOVE SHOULD BE CONSIDERED AS ONLY APPLICABLE TO MATERIAL CONFORMING TO THE CHARACTER OF THE SAMPLE UPON WHICH THE TESTS WERE MADE.

APPENDIX 2

Excerpt from L.D. Jarrard professional report: An appraisal of the Tom Reed tailings, 1959, Arizona Bureau of Geology and Mineral Technology mine file reports.

TOM REED TAILINGS

ASSAYS

Sample Location	Interval Feet	Ounces Per Ton Gold	Silver
1	0 to 4	.025	.08
	4 to 12	.060	.30
2	0 to 8	.030	.15
	8 to 15	.025	.08
	15 to 20	.025	.08
	20 to 26	.040	.21
3	0 to 8	.030	.15
	8 to 16	.063	.24
4	0 to 8	.071	.33
	8 to 16	.015	.16
	15 to 24	.015	.14
5	0 to 10	.083	.29
	10 to 19	.090	.31
6	0 to 4	.166	.38
7	0 to 11	.055	.10
	11 to 20	.030	.09
	20 to 28	.030	.13
	28 to 36	.025	.09
	36 to 45	.040	.18
	45 to 54	.055	.29
8	0 to 12	.040	.12
	12 to 21	.020	.17
	21 to 29	.030	.21
	29 to 37	.030	.15
	37 to 46	.065	.23
	46 to 54	.065	.32
9	0 to 8	.050	.10
10	0 to 6	.065	.13
11	0 to 5	.045	.12
12	0 to 6	.025	.09

Sample Location	Interval Feet	Ounces Per Ton Gold	Silver
13	0 to 10	.020	.18
	10 to 15	.035	.22
	15 to 20	.025	.17
14	0 to 5½	.01	.17
	5½ to 11	.015	.11
	11 to 16	.015	.23
	16 to 22	.015	.29
	22 to 30	.025	.22
	30 to 36	.025	.31
	36 to 42	.03	.38
	42 to 48	.03	.25
	48 to 56	.02	.17
	56 to 60	.02	.22
15	0 to 8	.02	.16
	8 to 16	.02	.18
16	0 to 8	.015	.14
	8 to 16	.01	.13
17	0 to 8	.015	.14
	8 to 16	.01	.14
18	0 to 6	.01	.10
	6 to 12	.02	.12
19	0 to 7	.015	.35
	7 to 13	.015	.32
	13 to 19	.02	.45
	19 to 26	.01	.42
	26 to 33	.02	.39
	33 to 40	.02	.16
	40 to 47	.01	.18
	47 to 53	.02	.18
	53 to 58	.035	.16
20	0 to 11	.025	.08
	11 to 20	.02	.25
	20 to 27	.035	.11
	27 to 33	.02	.12

APPENDIX 3

Copy of The Feasibility of a Custom/Toll Mill in Mohave County. Resource Base. CETA Mine Study, 1977, Arizona Bureau of Geology and Mineral Technology, Mohave County file.

THE FEASIBILITY OF A CUSTOM/TOLL MILL IN MOHAVE COUNTY

In 1974, the Mohave County Board of Supervisors, at the suggestion of Supervisor Don Aldridge, became interested in a custom mill project to stimulate economic activity in the County. A consulting firm was hired to make a preliminary, cursory examination to determine the feasibility of a custom mill here. A statement from the consultant, unsupported by factual data, was mailed to the Mohave County Board of Supervisors on October 15, 1975, in which a second phase was recommended of indepth feasibility studies of individual properties to establish the tenor and tonnage of available ores.

The County, with the assistance from the Arizona Department of Mineral Resources, developed a program to proceed on the development of a special mining library of descriptions of the mines and mineral deposits in the County. Then a short sampling program in a small area of the County was done for the purpose of soliciting Federal funds for the project. The proposed mining study plan was submitted in December, 1975. The project was approved by State and Federal governments in March, 1976, and three people were hired on April 7, 1976, through CETA funding. The report of that project in terms of procedures, work program and accomplishments, mine and mineral library, etc., has been written. That mine study project has been extended to the present under other than CETA funding.

The purpose of the more detailed mining study was to locate ore reserves of lead, zinc, copper, gold and silver in sufficient quantity and quality to amortize a small custom mill. The staff has accumulated the

mining data on Mohave County into a unified study that provides a valuable tool in assessing the feasibility for locating a custom mill operation in this County.

The findings of the work done to date, summarized on the attached tables, indicate that some 373,500 tons of reserves exist with an average total value, at current market prices, of $4.6 million. An additional 352,000 tons of reserves, in dumps and tailing, with an estimated average value of $106 per ton, are reported but not yet verified by sampling and surveying.

These promising results could lead to the establishment of a mill in Mohave County. The mill itself would provide employment opportunities, but it would chiefly provide a needed processing capacity for area small mine owner/operators. The jobs and economic stimulus offered by this project are urgently needed by Mohave County.

While the results to date are promising, some further study is required prior to being able to justify the estimated $500,000 investment required for the mill. Additional sampling to prove the fully documented reserves, and metallurgical testing to demonstrate effective extraction techniques are required. Marketing, operational and organizational factors also need to be considered. The attached outline provides more information on the remaining project requirements.

December 15, 1977

MOHAVE COUNTY MINE STUDY

Total average weighted assay

GOLD - SILVER	Harmon And Handy Base Price 10/26/77
COPPER - LEAD - ZINC	New York Stock Exchange Base Price 10/26/77

GOLD	$163.15 per ounce
SILVER	4.84 per ounce
COPPER	.605 per pound
LEAD	.31 per pound
ZINC	.315 per pound

PART II

RESOURCE BASE

SAMPLED ORE RESERVES

MINE NAME	TONS	VALUE PER TON
Monitor #5	5,900	$14.20
Summit Mine Dump	4,000	6.69
Alpha Mine Dump	4,000	15.77
Prosperity Mine Dump	2,100	15.14
Oro Plata Mine Dump	5,100	11.29
Tennessee Mine Dump	48,000	15.84
Minnesota-Connors Mine Dump & Jig Tails	2,000	55.36
Minnesota Mine Dump	1,900	34.17
Minnesota-Connors	11,000	30.26
Payroll Mine Dump	1,500	51.42
Payroll Mine Dump	2,000	14.13
Elkhart Mine Dump	3,000	28.54
Schuylkill Mine Dump	500	16.68
Roosevelt Mine Dump	22,000	4.72
Tennessee Tails	217,000	11.46
Copper Age (Underground blocked ore)	4,200	44.51
Copper Age (Underground probable ore)	1,500	53.86
TOTALS:	373,500	12.29

Note: Value per ton is the average weighted value, based on 10-26-77 market reports: Gold, $163.15 per oz.; Silver, $4.84 per oz.; Harmon & Handy. Copper, $.605 per lb.; Lead, $.31 per lb.; Zinc, $.315 per lb., NYC Commodity Exchange.

ORE RESERVES FROM SELECTED PRIVATE REPORTS AND

NOT SAMPLED BY MINE STUDY PROJECT (NOT VERIFIED)

MINE NAME	TONS	VALUE PER TON
Juno	50,000	$ 20.77
Hercules-Badger Mine Dump	25,000	35.08
C.O.D. Mine Dump	3,000	99.33
C.O.D. Tails	4,000	47.34
Golconda Mine Dump	40,000	62.51
Golconda Jig Tails	50,000	65.51
Copper Giant Probable Ore	30,000	42.73
Hackberry Extension	150,000	186.91
Totals	352,000	106.51

Note: Value per ton is the average weighted value.

MEASURED AND SAMPLED RESERVES DURING 1976-1977

IN THE CERBAT MOUNTAINS, ARIZONA

Mine	Type of Reserve	Estimated Short Tons	*Au	*Ag	Assay Cu,%	Pb,%	Zn,%
Minnesota-Connors	Mine Dump & Jig Tails	2,000	.063	6.63	0.15	0.40	1.38
	Mine Dump	1,900	.025	4.58	0.16	0.13	0.82
	Mine Dump	1,100	.018	3.44	0.09	0.39	1.14
		5,000					
Payroll	Mine Dump	1,500	.103	2.50	0.09	1.79	1.64
Payroll	Mine Dump	2,000	.020	0.92	0.08	0.35	0.52
Elkhart	Mine Dump	3,000	.059	0.94	0.04	1.73	0.50
Schuylkill	Mine Dump	500	.025	0.66	0.03	0.84	0.61
Roosevelt	Minus 3/4" Leached Tailing	22,000	----	----	0.39	----	----
Tennessee	Tailing	217,000	.012	0.33	0.03	0.19	1.01
Copper Age (Vein 2.4 feet wide)	Underground blocked	4,200	.031	2.26	----	1.50	3.05
	Underground probable	1,500	.035	3.24	----	1.62	3.56
	Total Measured Reserves:	256,700					
Oro Plata	Mine Dump	5,086	.006	1.28	----	.345	.315
Prosperity	Mine Dump	2,128	.010	1.77	----	.177	.61
Monitor #5	Tails	5,875	.005	.575	----	.305	1.335
Summit	Mine Dump	3,981	.004	.59	.035	.33	.115
Tennessee	Mine Dump	48,058	.007	.45	.06	.55	1.33
Alpha	Mine Dump	3,922	.011	1.89	.07	.54	.10
	Total:	69,050					
	Grand Total:	325,750					

* Troy ounces per ton

MEASURED AND SAMPLED RESERVES DURING 1976-1977

IN THE CERBAT MOUNTAINS, ARIZONA

Mine	Type of Reserve	Estimated Short Tons	Assay *Au	*Ag	Cu,%	Pb,%	Zn,%
Juno 1/	Mine Dump	50,000	.03	2.0	----	1.0	----
Hercules-Badger 1/	Mine Dump	25,000	.05	3.0	----	2.0	----
C.O.D. 2/	Mine Dump	3,000	.14	7.90	0.50	1.25	3.89
	Mine Dump	3,500	---------- not known ----------				
	Tailing	4,000	.12	3.74	----	0.29	1.25
		10,500					
Golconda 3/	Mine Dump	60,000	---------- not known ----------				
	Mine Dump	40,000	.09	1.6	0.3	0.5	5.3
	Jig Tailing	50,000	.09	1.3	0.2	0.62	6.08
	Table Tailing	25,000	---------- not known ----------				
Copper Giant 3/	Underground Reserve	30,000	.10	.50	2.0	----	----
Hackberry 3/	Underground Reserve	150,000	.10	25.0	----	8.0	----

1/ Written and oral communication from Richard V. Wyman, President Intermountain Exploration Company, Box 473, Boulder City, Nevada, 89005.

2/ Private report.

3/ Private reports in mine file in Mohave County Mining Library and in Phoenix DMR files.

* Troy ounces per ton.

ORE RESERVES IN THE CERBAT MOUNTAINS,

ARIZONA, FROM CITED SOURCES

NOT YET MEASURED OR SAMPLED

Mine	Type of Reserve	Estimated Short Tons	Assay *Au	*Ag	Cu,%	Pb,%	Zn,%
Juno 1/	Mine Dump	50,000	0.03	2.0	----	1.0	----
Hercules-Badger 1/	Mine Dump	25,000	0.05	3.0	----	2.0	00
C.O.D. 2/	Mine Dump	3,000	0.14	7.90	0.50	1.25	3.89
	Mine Dump	3,500	----------	----------	not known	----------	----------
	Tailing	4,000	0.12	3.74	----	0.29	1.25
		10,500					
Golconda 3/	Mine Dump	60,000	----------	----------	not known	----------	----------
	Mine Dump	40,000	0.09	1.6	0.3	0.5	5.3
	Jig Tailing	50,000	0.09	1.3	0.2	0.62	6.08
	Table Tailing	25,000	----------	----------	not known	----------	----------
		175,000					
Copper Giant 3/	Underground	30,000	.10	.50	2.0	----	----
Hackberry 3/	Underground	150,000	.10	25.0	----	8.0	----

1/ Written and oral communication from Richard V. Wyman, President, Intermountain Exploration Company, Box 473, Boulder City, Nevada 89005.

2/ Private report.

3/ Private reports on file in Mohave County Mining Library and in Phoenix DMR files.

* Troy ounces per ton

PART III

REMAINING PROJECT REQUIREMENTS

A. Metallurgical

1. Paper reconnaisance for proven flowsheets from published and private literature.
2. Summarize Mohave County ores by mineralogical type.
3. Solicit assistance in metallurgical testing of Mohave County ores from State and Federal agencies and private sources.
4. Examine Cymet process, Liquid ion exchange and other hydrometallurgical processes for recovery, refining, efficiencies and economics of Mohave County ores and concentrates.
   A. With respect to pad or vat leaching at or near dumpsite or minesite.
   B. With respect to custom or toll milling and refining at a single site.

B. Continue present sampling program to verify, prove and sample additional ore reserves shown under Part II.

1. Tennessee tailing are marginal reserve at best.
2. Discuss partial amortization of a custom mill from tailing without profit, (at break-even basis).

C. Examine and group tailing from metallurgical tests to determine probable by-product sales of the following:

1. Fertilizer material
2. Refractory sands
3. Pozzolan material for use in concrete
4. Binder material for hot-mix road surfacing
5. The value of any by-product sales will not be used in making feasibility studies.

PART IV

If steps II and III yield positive results, ascertain those mines from which production is economically feasible based on the following estimates per ton of ore:

A. Operating costs to mine and process material.

B. Market survey

   1. Products and uses.

   2. Location of markets.

   3. Present and estimated future demand.

   4. Present and estimated future prices.

C. Capital costs of mill, lands, water, power, royalties, etc.

D. Cost of startup and shakedown, delay, contingencies, etc.

E. Cost of borrowed capital to mine or purchase and process the ore.

F. Estimated administrative and overhead costs.

G. Net selling price of all products.

H. Determine net profit per ton before taxes.

PART V

If step IV yields favorable results and sufficient ore reserves exist for a five (5) year operation of an approximate 100 ton per day custom mill or plant then:

A. Examine organizational structure with respect to one or a combination of:

   1. Private sector ownership.

   2. Public sector ownership.

   3. Small mine owners co-op.

B. Establish marketing specifications in the most favorable area for all products.

C. Shop for the most favorable mill or plant site with respect to transportation to and from all mines involved and transportation of all products to respective market.

D. Provide for a permanent and adequate water supply.

E. Provide for adequate tailing and other waste disposal in consonance with environmental requirements.

F. Provide for a capable labor force.

G. Arrange for capital to develop and mine ore reserves and to construct mill or plant.

H. Provide for legally binding agreements from all participants, to provide mill feed to cover the amortization period.

I. Work out schedules of purchase or toll charges for various types of ores and schedules for production from the various reserves.