Arizona Geological Survey
125 Years
1888–2013

CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

GEOLOGY OF THE SQUAW PEAK PORPHYRY COPPER-MOLYBDENUM DEPOSIT, YAVAPAI COUNTY, ARIZONA

by

Robert Ralph Roe

A Thesis Submitted to the Faculty of the

DEPARTMENT OF GEOSCIENCES

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 6

See University of Arizona Department of Geosciences for Theses

Squaw Creek Copper, Yavapai Co.

Exploration data from Phillips Petroleum during 1968 - 1972

Metallurgical progress report and results

and

Geochemical Survey report

GEOCHEMICAL SAMPLING PROGRAM

SQUAW PEAK, ARIZONA

(1064-ID)

March 10, 1969

By

D. J. Kubish

A geochemical soil sampling program was undertaken during January and February, 1969 covering part of our acreage on the Squaw Peak project in Central Arizona. M. R. Sauvola and D. J. Kubish conducted the survey. A total of 719 samples were taken on 707 locations. The area sampled covers approximately 5200 feet in a north-south direction by 3600 feet in an east-west direction. Note the Base Map for Geochemical Sampling.

Field Procedure:

The method of sampling consisted of taking two to three soil samples near each location at a depth of one to three inches. Each sample location was spotted on an aerial photograph, as well as flagged and numbered in the field. The sample locations are approximately 100 feet apart on each line. The lines are parallel, east-west trending and about 300 feet apart except for lines 16 and 17 which are about 200 feet apart.

Analyses Methods:

The samples were analyzed in Reno, Nevada by Rocky Mountain Geochemical Corporation for trace elements of copper, zinc and molybdenum. Copper and zinc analyses were determined by atomic absorption. That of molybdenum was determined colorimetrically.

A mercury analysis was run on the first shipment of 105 samples. These covered lines 16, 17 and part of 18. The results from these analyses showed no significant trend and no further samples were tested for mercury. Note the Mercury Geochemical Contour Map.

The copper analyses in parts per million (ppm) ranged from 15 to 3700. Contour intervals a 1000 ppm beginning with 1000 ppm. Additional

250 ppm and 500 ppm contours are used to further define anomalous conditions. Note the Copper Geochemical Contour Map.

The results from the zinc analyses ranged from 40 ppm to 770 ppm. Contours are based on 100 ppm intervals starting with 100 ppm. Note the Zinc Geochemical Contour Map.

The molybdenum analyses ranged from less than one (-1) ppm to 155 ppm. Contour intervals are 20 ppm beginning with 20 ppm. A 10 ppm contour is also used to define minor anomalies particularly those adjacent and updip from the Verde Fault. Note the molybdenum Geochemical Contour Map.

Analyses Results:

The contoured results of the copper, zinc and molybdenum analyses show an anomalous high trend striking approximately N 40° W. The trend indicates three areas of interest.

(1) Near the intersection of the N 40° W trend and the Verde Fault a copper, zinc and molybdenum high occurs. This is within the eastern nine to ten sample locations of lines 8, 9 and 10. The copper high, thus far defined, peaks at 1000 ppm. However, the possibility of significant copper content in this area, resulting from the Verde Fault intersecting the trend, is worthy of further sampling and possible core exploration. Further sampling in this area would more fully define the anomalous character and set its limits west of the fault.

(2) The copper high as defined by the 3000 ppm contour in the area of DDH #1 and DDH #6 covers an area of approximately 1150 feet in a north-south direction by 1000 feet in an east-west direction. Overlapping of the 3000 ppm copper contour and the 20 ppm contour of molybdenum restricts this as an area

of prime interest. DDH #1 was collared in the south-central part of this anomaly. DDH Nos. 3, 4 and 5 were collared to the west of this area and contained no significant thickness of copper enrichment. DDH #6 was located with the aid of the above geochemical control and is located near the center of the 3000 ppm copper anomaly. DDH #1 carried 0.488% copper to a depth of 250 feet. DDH #6 through the first hundred feet of core showed an enriched chalcopyrite and molybdenite content along fractures and to a lesser degree disseminated within the host rock. This enrichment is similar to that found in DDH #1. No deeper core was observed in DDH #6 and assay results are pending. If DDH #6 contains a favorable copper content over a significant interval, the above anomalous high area may be used as a guide for future drilling.

(3) The 1000 ppm copper contour north from the anomalous area surrounding DDH #6 continues in an approximate N 40° W trend. Molybdenum highs are within this extension at the western edge of sampling locations of lines 22 and 24 as well as locations 8 and 9 of line 25. Further sampling to the west and north of the 1000 ppm copper limits should determine the quality and extent of this anomaly.

Conclusions and Recommendations:

The results of the Squaw Peak geochemical program have been very encouraging. An anomalous copper - molybdenum high around DDH #1 and #6 has been defined and may provide a restricted area for future drilling. Two areas, one each at the extremities of the N 40° W trend, indicate prospective areas for further geochemical sampling.

An addition of twenty soil samples are recommended in the area of the intersection of the Verde Fault and the N 40° W trend. Westward extension of lines 22 through 25 is recommended as well as two additional lines to the north from line 25. About 160 sample locations in this area are suggested. Future geochemical lines should be separated by not more than 200 feet.

October 8, 1971

PHILLIPS 66

RECEIVED OCT 14 1971 RENO

INTER-OFFICE CORRESPONDENCE / SUBJECT: Squaw Peak Project No. MD 1064

To: Mr. Robert Forest
From: H. A. Franco

PROGRESS REPORT No. 3

The following report covers detailed test work conducted on sample No. 1 and additional test work conducted on sample No. 4 of the Squaw Peak ore.

SUMMARY

The results of the test work herein reported indicate the following:

a. The flotation procedure used to float ore No. 4 is equally effective in floating ore No. 1.
b. Both ore samples were too low in tungsten content to consider them a by-product source ore for Scheelite.
c. It is possible to upgrade ore No. 4 to approximately 0.4 percent Cu and 0.03 percent MoS2 by differential grinding; This means rejecting 25 percent of the tonnage with a grade of 0.15% Cu and 0.02 MoS2. This approach might be worth investigating.
d. Flotation appears to be the best way to treat the ores and we can expect 80 to 85 percent Cu and MoS2 recovery by using this method of treatment.

DISCUSSION

1. Chemical analyses of sample No. 1 was as follows:

	Percent	PPM	Expected
Cu	0.24		0.28
MoS2	0.028		0.014
W		5	

The MoS2 content was much higher than expected based on the calculated composite core samples. This resulted in low MoS2 recovery for the flotation tests which were conducted before the analysis was made, and no enough reagent was used to float the MoS2 in the ore.

2. The following flotation tests were conducted on ores Nos. 1 and 4:

a. Test No. 13FT8: Test No. 13FT8 was conducted in order to investigate the amenability of ore No. 1 to the flotation procedure used for test No. 6FT5 on ore No. 4. Results were as follows:

Product	Description	Wt. %	Cu %	Cu Distr.	MoS2 %	MoS2 Distr.
	Heads, Chem		0.24		0.028	
	Heads, Calc.	100.00	0.26	100.00	0.025	100.00
1	Cln. 2 Conc	0.65	25.50	63.36	1.068	27.83
2	Cln. 2 Tail	1.25	2.75	12.98	0.332	16.94
3	Cln. 1 Tail	5.84	0.24	5.34	0.049	11.69
4	Scav Conc	4.19	0.31	4.96	0.070	11.69
5	Ro Tail	88.07	0.04	13.36	0.009	31.85
1,2,3	Ro Conc	7.74	2.76	81.38	0.181	56.46

These results are compatible with the results of test No. 6FT5 as far as Cu grade and recovery are concerned. The MoS_2 recovery was low but this is due in all probability to low collector level, even though it could also be incomplete liberation.

Test No. 14FT9: In an attempt to improve sulphide mineral recovery, a test was conducted using Z-6 (Potassium Amyl Xanthate) as collector. The Z-6 by itself did not appear to give a satisfactory froth using Dowfroth 250 as frother. To improve the float Z-200 was added to the pulp to make it a ratio of two Z-6 to one Z-200. Results were as follows:

Product	Description	Wt. %	Cu %	Cu Distr.	MoS_2 %	MoS_2 Distr.
	Heads, Chem		0.24		0.028	
	Heads, Calc	100.00	0.26	100.00	0.023	100.00
1	Cln 2 Conc	0.78	21.00	62.84	1.068	35.78
2	Cln 2 Tail	0.33	5.90	7.28	0.759	10.78
3	Cln 1 Tail	2.21	0.75	6.50	0.113	10.78
4.	Scav Conc	5.23	0.47	9.20	0.085	18.96
5	Ro Tail	91.45	0.04	14.18	0.006	23.70
1,2,3	Ro Conc.	3.32	6.02	76.62	0.401	57.34

Examination of the products revealed that the cleaner 2 concentrate was clean but high in pyrite.

Test No. 16FT11: Test No. 16FT11 was also conducted on ore No. 1. For the test the level of reagent was kept the same, but the ratio of Z-6 to Z-200 was one to one, in an attempt to increase Cu selectivity. Also the level of Dowfroth 250 was kept the same. Results were as follows:

	Heads, Chem		0.24		0.028	
	Heads, Calc	100.00	0.26	100.00	0.027	100.00
1	Cln 2 Conc	0.75	21.50	62.16	1.184	33.46
2	Cln 2 Tail	0.38	5.25	7.72	0.734	10.53
3	Cln 1 Tail	3.31	0.41	5.41	0.070	8.65
4	Scav Conc	2.74	0.67	6.95	0.190	19.55
5	Ro Tail	92.82	0.05	17.76	0.008	27.81
1,2,3	Ro Conc	4.42	4.39	75.29	0.315	52.64

Results were comparable with those of test No. 16FT11, and not as satisfactory as those of test No. 13FT8.

Test No. 15FT10: Test No. 15FT10 was conducted on ore No. 4 and using the same reagent combination as used for test No. 16FT11. Result were as follows:

	Heads, Chem		0.31		0.021	
	Heads, Calc	100.00	0.36	100.00	0.021	100.00
1	Cln 2 Conc	1.19	18.50	60.44	1.043	59.62
2	Cln 2 Tail	0.69	4.55	8.52	0.337	11.06
3	Cln 1 Tail	3.28	0.47	4.12	0.035	0.96
4	Scav Conc	1.62	0.84	3.85	0.125	10.57
5	Ro Tail	93.22	0.09	23.08	0.004	17.79
1,2,3	Ro Conc	5.16	5.16	73.08	0.289	71.64

Even though the cleaner two concentrate was not as clean as for test No. 16FT11, its pyrite content was much higher than for test No. 6FT5.

These results indicate that additional pyrite depressants should be used along with Z-6 as collector, even in combination with Z-200. Also, the Dowfroth 250 quantity required with the Z-6/Z-200 combination is higher than the quantity required with Z-200 alone.

In conclusion, it appears that the best combination tried to process the Squaw Peak ore is the use of lime as pyrite depressant, and Z-200 as the copper-molybdenum collector for the bulk float; Diesel fuel can be used to improve MoS_2 recovery in the scavenger float and in both floats Dowfroth 250 is an effective frother. H_2SO_4 can be used as pH modifier in the scavenger float.

Detailed laboratory sheets for tests Nos. 6FT5 and 15FT10 Squaw Peak ore No. 4; and tests Nos. 13FT8, 14FT9, and 16FT11 Squaw Peak ore No. 1; are attached to this report.

3. A grinding-classification test was conducted on a sample of Squaw Peak Ore No. 4.

   For this test the following points were taken into account:
   a. The copper is present as chalcopyrite, Hardness 3½-4.
   b. The chalcopyrite shows completely liberated particles starting at 48 mesh, and it is a brittle mineral.
   c. Pyrite is present in small amounts. Even though the pyrite is also brittle, it has a hardness of 6-6½.
   d. The main impurities are: quartzite, hardness 7; the feldspars, hardness 6-6½; and the micas. The micas are soft but usually brakes in plates, with one dimension several times the other from a sectional point of view.

   Assuming that the chalcopyrite will be reduced in size faster than any other component of the same size fraction, a sample of minus 10 mesh ore was ground to nominal 48 mesh in one pass. The results were as follows:

Mesh	Cumulative % Retained				
	Wt.	Cu		MoS_2	
Tyler	%	%	Distr.	%	Distr.
+48	0.38	0.092	0.096	0.018	0.276
+65	2.66	0.086	0.627	0.025	2.679
+100	10.46	0.111	3.188	0.020	8.365
+150	24.95	0.151	10.323	0.020	20.110
+200	39.37	0.187	20.186	0.016	33.550
+270	50.29	0.218	30.046	0.021	43.728
+325	54.60	0.234	34.952	0.022	47.918
-325	45.40	0.523	65.002	0.028	52.082
Heads	100.00	0.366	100.000	0.025	100.000
	Cumulative % Passing				
-48	99.62	0.367	99.904	0.025	99.724
-65	97.34	0.373	99.373	0.025	97.321
-100	89.54	0.395	96.812	0.025	91.632
-150	75.05	0.437	89.677	0.026	79.890
-200	60.63	0.481	79.814	0.027	66.450
-270	49.71	0.514	69.954	0.028	56.272
-325	45.40	0.523	65.002	0.028	52.082

What the test tell us is that by differential grinding, we can upgrade the ore from 0.36% Cu to as much as 0.52% Cu, in a product containing 65% of the Cu in the mined ore and 45% of the weight.

One advantage of this system is that we can pick the economical grade of ore to be processed, and store the discard until such a time it becomes economical.

Going back to page 3, a hypothetical case would be as follows:

a. Grinding of the run-of-mine ore to nominal 48 mesh, in open circuit.
b. Classification of the ground ore on 150 mesh.
c. Storage of the plus 150 mesh in a site adjacent to the plant from which it can be pumped back to the plant. Oxidation of the sulphides should not be much of a problem because:
   I. At that mesh size there are mostly middlings, and only part of the sulphide surface will be exposed.
   II. Regrinding of the ore will remove any oxide coating that might form on the surface of the exposed sulphides.
d. For our hypothetical case the material balance would be:
   I. Ore reserves: 30,000,000 tons. 0.36% Cu, 0.025 MoS2.
   II. Mining rate: 5,000TPD, 300 days/year, 20 years.
   III. Plus 150 mesh to storage: 1,250TPD of o.15% Cu and 0.020% MoS2. This represents 10% of the Cu and 20% of the MoS2 in the run-of mine ore.
   IV. Minus 150 to the flotation plant: 3,750TPD of 0.437% Cu and 0.026% MoS2.This represents 90% of the Cu, 80% of the MoS2 and 75% of the tonnage of the run-of-mine ore.
   V. I think that under this circunstances we can expect 85 to 90 percent Cu and MoS2 recovery, and that the milling cost will be reasonable enough to make it attractive at the present prices.
   VI. The system will require much more metallurgical study and very detailed mine planning. However, I feel that we have the tools to do both.

Graph No. 1 illustrates the cumulative % passing figures.

PHILLIPS PETROLEUM COMPANY
Minerals Division

H.A. Franco, P.E.
Metallurgist

Avon Refinery
June 5, 1969

INTER-OFFICE CORRESPONDENCE / SUBJECT: SQUAW PEAK PROJECT
METALLURGICAL PROGRESS REPORT
MONTH OF MAY 1969

R. T. Forest:

No further tests were run. The results of test 6-3 were recalculated on the basis of rerun assays from Union Assay Office. The calculation sheet is attached. The differences are quite pronounced. Mr. Wanlass, of the Union Assay Office, was at a loss to explain the original error and very apologetic and appreciative of the opportunity to rerun the samples. In a case like this, the error shows up reasonably quickly in the metallurgical balance. However, the incident does emphasize that all methods of analysis are subject to error and that a relatively large number of cases or samples is probably one of the best protections against wrong information.

The results still leave a lot to be desired in terms of recovery on cleaning, but unless you advise otherwise, I won't do any more on this until we get the better grade feed which you said we should expect. The rougher recovery at 70% on copper is certainly poor but considering the tailing of less than .1%, I don't think we can expect substantial improvement, especially as about 20% of that is in oxide form.

I am attaching with the original a copy of the revised assay certificate.

HSF:md

H. S. Fowler

Attachments
To Forest: Revised Assay Certificate
Test Report on 6-3

cc: D. C. Arnold
C. N. Holmes
S. R. Havenstrite
K. J. Green

Attachment
Test Report on 6-3

PHILLIPS PETROLEUM CO. - AVON LAB. FLOTATION TEST REPORT

Objective: Repeat 6-2 but (1) grind 60 M (2) Combine F1 F2 F3 (3) omit Z-11 (4) Regrind Con & clean twice

Test No. Avon
Date Apr 15 6
Operator HSf

Sample: Squaw Peak 1 2Kg. H_2O 1 L

TEST CONDITIONS

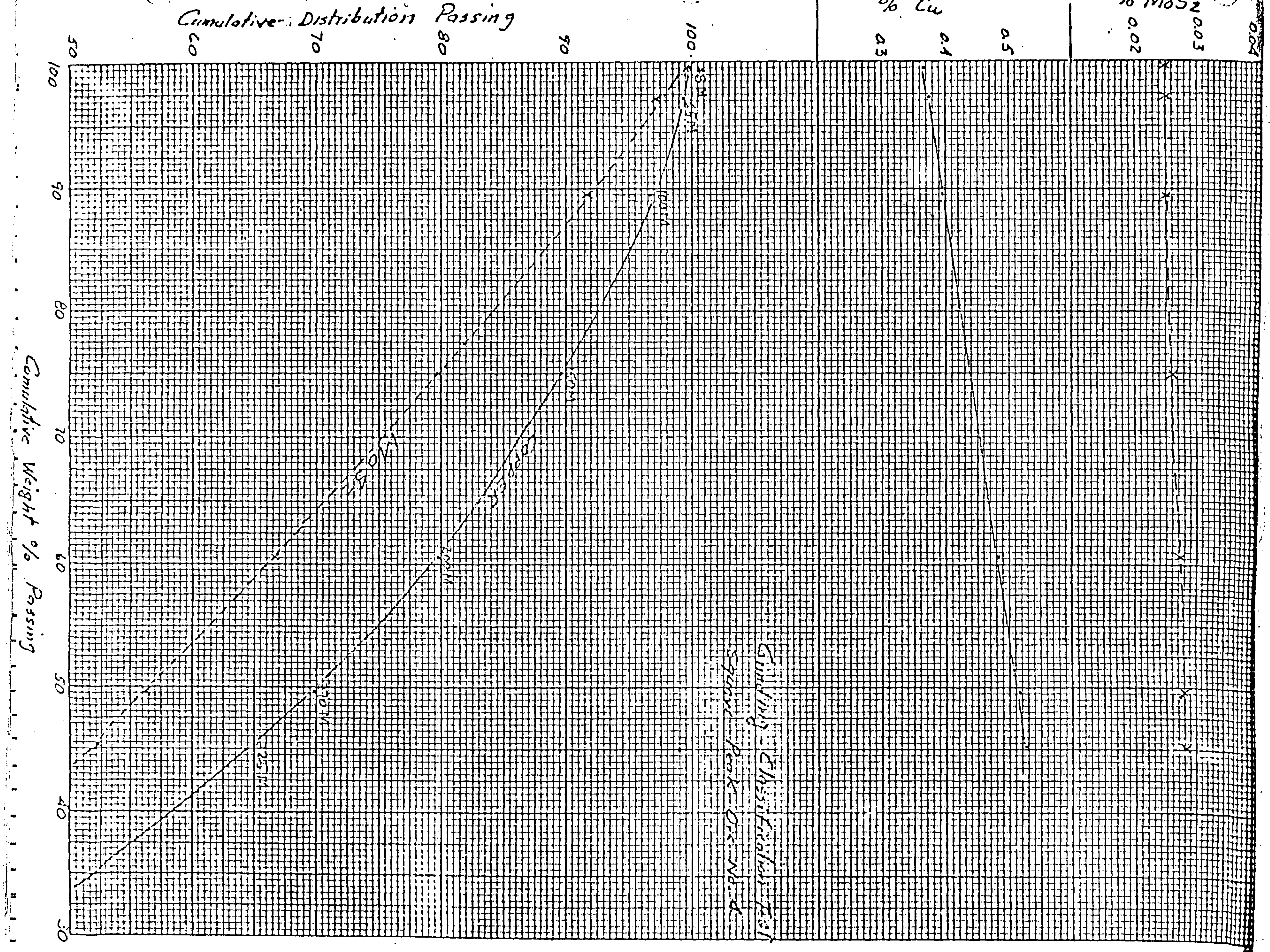
OPERATION Flot RPM	G1 BM	K1 1800	F1 1800	F2 1800	F3 Scav		G2 JAR	F4 CL 1 1300	F5 CL 2	F6 CL 3 1300
Time - Min.	60	5	1	8	5		15	6	3	±3
% Solids	67	33.4								
pH		11-9.2-10.5	10.4	9.9	9.3			7-11-9.3	8.8-11-10.5	10.7-10.1
Temperature 80°F	Amb				80F					
Destination			G2	G2	FINAL			F5	F6	FINAL
Reagents, Lb./Ton										
LIME Hyd	4.0	0.5						0.4	0.3	0.25
SO_2		1.0						0.1		
Dowfroth 250		.003								
Z-200		.028		.014	.007			0.028		

METHOD OF

TEST PRODUCT	% Wt.	Analysis Cu	Mo	UNION RERUN	Ratio Cu/Mo		(% Wt.)(Analysis) Cu	Mo	OxCu			Distribution Cu	Mo	OxCu
Cu ¢ 3 Con	0.54	23.45	1.98	ox Cu.	12		12.7	1.07				45.0	38.4	% of
Cu ¢ 3 Tail	0.79	7.26	0.50		15		2.1	0.14				7.4	5.0	Heads
Cu C 2 Tail	1.00	2.78	0.21		13		2.78	0.21				9.8	7.5	
Cu ¢ 1 Tail	2.67	0.91	.046		20		2.43	.12				8.6	4.3	
CALC Rougher	4.50	4.46	0.34				20.01	1.54				70.8	55.2	
Cu Scav Con (F3)	1.60	0.40	.018		22		0.64	.03				2.3	1.1	
TAIL	93.90	0.081	.013	.018	6		7.60	1.22	1.70			26.9	43.8	5.9
CALC HEAD	100.00	0.282	.028		10		28.2	2.77				100.0	100.1	
A+B = Cu ¢ 2 Con	.83	17.4	1.46				14.80	1.21				52.4	43.4	
A+B+C = Cu ¢ 1 Con	1.83	9.60	0.78				17.58	1.42				62.2	50.9	
Assay ...		.283	.024		12									

Remarks: F1 Might do with less frother. Copper flots fast. F2 possibly higher Mo/Cu ratio than F1.
B (F6T) Value above adjusted for dilution. See Back

FORM
... 1 69


Cumulative Distribution Passing
50
60
70
80
90
100
% Cu
0.3
0.4
0.5
% MoS2
0.02
0.03
0.04
Cumulative Weight % Passing
100
90
80
70
60
50
40
30
MoS2
COPPER
Grinding - Classification Test
Squaw Peak Ore No. 4

METALLURGICAL LABORATORY
PHILLIPS PETROLEUM COMPANY
MINERALS DIVISION

Test No. 6FT5 Sheet No 1 Date: 4-27-7

Project: MD 1064: Squaw Peak, Arizona

Objective: Determine optimum bulk Mo-Cu recovery by flotation | Grind: 8"x8" ϕ Ball mill | Media: Balls

Sample: Squaw Peak No. 4 | Wt.: 2000g/1600cc | Flot Mach.: Denver D-1 | Imp. Diam.: 2 ½-in

Variable	Operation									
	BM	C1	F1	C2	SF	CL1	CL2			
Time, Min.	45	5	3	3	3					
% Solids	55.6	33.5								
RPM	65	2100	2100	2100	2100	1300	1300			
pH	10.9	10.0	10.0	10.0	10.0	10.0	10.8			
Destination C/T	C1	F1	CL1 / C2	SF	C / T	CL2 / T	C / T			
Reagents: lb. per ton of Test Feed										
Lime	3					0.2	0.5			
Z-200		0.049		0.025						
DF-250		0.012		0.006		0.006	0.006			
Diesel Fuel					0.03					

Product	Weight Grams	Weight %	Cu %	Cu Units	Cu Dist	MoS_2 %	MoS_2 Units	MoS_2 Dist
Heads, Chem.			0.31			0.021		
Heads, Calc.		100.00	0.37	37.42	100.00	0.024	2.361	100.00
Cl2 Conc		0.77	28.00	21.56	57.61	1.348	1.038	43.96
Cl2 Tail		0.36	10.00	3.60	9.62	0.881	0.317	13.43
Cl1 Tail		4.30	0.69	2.97	7.94	0.060	0.258	10.93
Scav. Conc.		4.60	0.56	2.99	7.99	0.104	0.478	20.25
Ro Tail		89.97	0.07	6.30	16.84	0.003	0.270	11.43
Ro Conc.		5.43	5.18	28.13	75.17	0.297	1.613	68.32

Remarks

METALLURGICAL LABORATORY
PHILLIPS PETROLEUM COMPANY
MINERALS DIVISION

Test No. 15FT10 Sheet No 1 Date: SEP 15

Project: MD 1064: Squaw Peak, Arizona

Objective: Determine optimum Bulk Cu-Mo recovery by Flotation		Grind: 8"x8" Ø B. mill	Media: Balls 3
Sample: Squaw Peak No. 4	Wt: 2000 g / 1600 cc	Flot Mach.: Denver D-1	Imp. Diam.: 2 1/2-in.

Variable	BM	C1	F1	C2	SF	CL1	CL2
	Operation						
Time, Min	45	5	3	3	1 1/2	1 1/2	1 1/2
% Solids	55.6%	33.5%					
RPM	65	2100	2100	2100	2100	1300	1200
pH	10.8	10.5	10.5	10.3	9.2	10.9	8.7
Destination C/T	C1	F1	CL1 / C2	SF	C / T	CL2 / T	C / T
Reagents: lb. per ton of Test Feed							
Lime	3g 3					0.5g 0.5	
Z-6		4cc 0.040					
Z-200		2d 0.050					
DF-250		1d 0.022		1wd 0.006	1d 0.022	1wd 0.006	
Diesel Fuel				2d 0.050			
H_2SO_4					4cc 0.800		

Product	Weight Grams	Weight %	Cu %	Cu Units	Cu Dist.	MoS_2 %	MoS_2 Units	MoS_2 Dist.
Heads Chem.			0.31			0.021		
Heads Calc	1998.3	100.00	0.36	0.364	100.00	0.021	0.0208	100.00
54 Cln. 2 Conc	23.8	1.19	18.50	0.220	60.44	1.043	0.0124	59.62
55 Cln 2 Tail	13.8	0.69	4.55	0.031	8.52	0.337	0.0023	11.06
56 Cln 1 Tail	65.5	3.28	0.47	0.015	4.12	0.035	0.0002	0.96
57 Scav. Conc	32.4	1.62	0.84	0.014	3.85	0.125	0.0022	10.57
58 Ro. Tail	1862.8	93.22	0.09	0.084	23.08	0.004	0.0037	17.79
Ro. Conc.		5.16	5.16	0.266	73.08	0.289	0.0149	71.64

Remarks: Conc. requires regrinding and cleaning prior to Mo-Cu Sept.

Test No. 13FT8 Sheet No 1

METALLURGICAL LABORATORY
PHILLIPS PETROLEUM COMPANY
MINERALS DIVISION

Date: SEP 14

Project: Squaw Peak, Arizona MD-1064

Objective: Determine Optimum Cu-Mo-W recoveries by flot. | Grind: 8"x8" Ball Mill | Media: Balls : 31

Sample: Squaw Peak No. 1 | Wt.: 2000 g/1600 cc | Flot Mach.: Denver D-1 | Imp. Diam.: 2 1/2 -in.

Variable	Operation						
	BM	C1	F1	C2	SF	CL1	CL2
Time, Min	45	5	3	3	3	1 1/2	1 1/2
% Solids	55.6%	33.5%					
RPM	65	2100	2100	2100	2100	1400	1300
pH	10.8	10.2	10.2	10.2	10.2	11.2	8.7
Destination C/T	C1	F1	CL1 / C2	SF	C / T	CL2 / T	C / T

Reagents: lb. per ton of Flotation feed

Reagent	BM	C1	F1	C2	SF	CL1	CL2
Lime	3					0.5	
Z-200		2d 0.049		1d 0.025			
DF-250		2dw 0.012		1wd 0.006		1wd 0.006	
Diesel Fuel				1d 0.015			

Product	Weight Grams	Weight %	Cu %	Cu Units	Cu Dist.	MoS2 %	MoS2 Units	MoS2 Dist.
Heads, Chem.			0.24			0.028		
Heads, Calc	2,003.2	100.00	0.26	0.262	100.00	0.025	0.0248	100.00
14 Cln. 2 Conc	13.0	0.65	25.50	0.166	63.36	1.068	0.0069	27.83
15 Cln 2 Tail	25.1	1.25	2.75	0.034	12.98	0.332	0.0042	16.94
16 Cln 1 Tail	116.9	5.84	0.24	0.014	5.34	0.049	0.0029	11.69
17 Scav. Conc.	83.9	4.19	0.31	0.013	4.96	0.070	0.0029	11.69
18 Ro. Tail	1764.3	88.07	0.04	0.035	13.36	0.009	0.0079	31.85
Ro Cnc.		7.74	2.76	0.214	81.38	0.181	0.0140	56.46

Remarks: CL1 30 sec. cond. before float; Cl1 hi pH to improve Cu selectivity; Cl2 Low pH No Selectivity - Cln. 2 Conc. with impurities; will need regrind and cleaner prior to Cu-M

Test No. 14FT9 Sheet No 1

METALLURGICAL LABORATORY
PHILLIPS PETROLEUM COMPANY
MINERALS DIVISION

Date: SEP 15

Project: MD-1064: Squaw Peak, Arizona

Objective: Determine optimum bulk Cu-Mo recovery by flotation		Grind: 8" x 8" ϕ B. Mill	Media: Balls
Sample: Squaw Peak No. 1	Wt: 2000 g/1600 cc	Flot Mach.: Denver D-1	Imp. Diam.: 2 1/2 in.

Variable	BM	C1	F1	C2	SF 2)	CL1	CL2				
	Operation										
Time, Min.	45	8 1)	4	3	2 - 1	1 1/2	1 1/2				
% Solids	55.6%	33.5%									
RPM	65	2100	2100	2100	2100	1300	1300				
pH	10.5	10.2	10.2	9.9	9.9-7.8	10.6	8.3				
Destination C/T	C1	F1	CL1/C2	SF	C/T	CL2/T	C/T				
Reagents: lb. per ton of Test Feed											
Lime	3					0.5					
Z-6		8cc 0.060									
DF-250		2wd + 1d 0.028		1wd 0.006		1wd 0.006					
Diesel Fuel				1d 0.015							
Z-200		1d 0.025		1d 0.025							
H_2SO_4					5cc 1.000						

Product	Weight		Cu			MoS_2		
	Grams	%	%	Units	Dist.	%	Units	Dist.
Heads Chem.			0.24			0.028		
Heads Calc.	2003.6	100.00	0.26	0.261	100.00	0.023	0.0232	100.00
49 Cln. 2 Conc.	15.7	0.78	21.00	0.164	62.84	1.068	0.0083	35.78
50 Cln. 2 Tail	6.7	0.33	5.90	0.019	7.28	0.759	0.0025	10.78
51 Cln 1 Tail	44.3	2.21	0.75	0.017	6.50	0.113	0.0025	10.78
52 Scav. Conc.	104.6	5.23	0.47	0.024	9.20	0.085	0.0044	18.96
53 Ro. Tail.	1832.3	91.45	0.04	0.037	14.18	0.00[illegible]	0.0055	23.70
Ro. Conc.		3.32	6.02	0.200	76.62	0.401	0.0133	57.34

Remarks 1) Cond. 6 min. Z-6; Poor froth mostly Cu, added 3cc Z-6 more and 1d Z-200, Cond. 3 more min. Floated 4 min.; 2) Cond. 3 min. poor froth, + 1d 250: ok; Float 2 min., Lowered pH to 7.8 5cc 20g/100 H_2SO_4
[illegible]

METALLURGICAL LABORATORY
PHILLIPS PETROLEUM COMPANY
MINERALS DIVISION

Test No. 16FT11 Sheet No. 1 — Date: SEP 16 1[illegible]

Project: MD1064; Squaw Peak, Arizona

Objective: Determine optimum Bulk Cu-Mo recovery by flotation		Grind: 8"x8" Ball mill	Media: Balls
Sample: Squaw Peak No. 1	Wt: 2000g/1600cc	Flot Mach.: Denver D-1	Imp. Diam.: 2 1/2-in.

Variable	BM	C1	F1	C2 (1)	SF (2)	CL1	CL2
	Operation						
Time, Min	45	5	3	3	2		
% Solids	55.6%	33.5%					
RPM	65	2100	2100	2100			
pH	10.8	10.4		8.6		11.0	
Destination C/T	C1	F1	CL1 / C2	SF	C / T	CL2 / T	C / T
Reagents: lb. per ton of Test Feed							
Lime	3					0.5	
Z-6		3cc 0.030					
Z-200		1d 0.025					
DF-250		1d 0.022		1d 0.022		1wd 0.006	
H_2SO_4				4.5cc 0.900			
Diesel Fuel				1d 0.015			

Product	Weight Grams	Weight %	Cu %	Cu Units	Cu Dist	MoS_2 %	MoS_2 Units	MoS_2 Dist.
Heads Chem.			0.24			0.028		
Heads, Calc.	2,003.1	100.00	0.26	0.259	100.00	0.027	0.0266	100.00
59 Cln. 2 Conc	15.1	0.75	21.50	0.161	62.16	1.184	0.0089	33.46
60 Cln 2 Tail	7.6	0.38	5.25	0.020	7.72	0.734	0.0028	10.53
61 Cln 1 Tail	66.3	3.31	0.41	0.014	5.41	0.070	0.0023	8.65
62 Scav. Conc.	54.9	2.74	0.67	0.018	6.95	0.190	0.0052	19.55
63 Ro Tail	1859.2	92.82	0.05	0.046	17.76	0.008	0.0074	27.81
Ro Conc.		4.44	4.39	0.195	75.29	0.315	0.014	52.64

Remarks 1) Reagents added after lowering pH.; 2) after S.F. added 1g Lime + 2d pine oil; 10.5 pH

October 8, 1971

INTER-OFFICE CORRESPONDENCE / SUBJECT: Squaw Peak Project No. MD 1064 - 9

To: Mr. Robert Forest
From: H. A. Franco

PROGRESS REPORT No. 3

The following report covers detailed test work conducted on sample No. 1 and additional test work conducted on sample No. 4 of the Squaw Peak ore.

SUMMARY

The results of the test work herein reported indicate the following:

a. The flotation procedure used to float ore No. 4 is equally effective in floating ore No. 1.
b. Both ore samples were too low in tungsten content to consider them a by-product source ore for Scheelite.
c. It is possible to upgrade ore No. 4 to approximately 0.4 percent Cu and 0.03 percent MoS2 by differential grinding; This means rejecting 25 percent of the tonnage with a grade of 0.15% Cu and 0.02 MoS2. This approach might be worth investigating.
d. Flotation appears to be the best way to treat the ores and we can expect 80 to 85 percent Cu and MoS2 recovery by using this method of treatment.

DISCUSSION

1. Chemical analyses of sample No. 1 was as follows:

	Percent	PPM	Expected
Cu	0.24		0.28
MoS2	0.028		0.014
W		5	

The MoS2 content was much higher than expected based on the calculated composite core samples. This resulted in low MoS2 recovery for the flotation tests which were conducted before the analysis was made, and no enough reagent was used to float the MoS2 in the ore.

2. The following flotation tests were conducted on ores Nos. 1 and 4:

a. Test No. 13FT8: Test No. 13FT8 was conducted in order to investigate the amenability of ore No. 1 to the flotation procedure used for test No. 6FT5 on ore No. 4. Results were as follows:

Product	Description	Wt. %	Cu %	Cu Distr.	MoS2 %	MoS2 Distr.
	Heads, Chem		0.24		0.028	
	Heads, Calc.	100.00	0.26	100.00	0.025	100.00
1	Cln. 2 Conc	0.65	25.50	63.36	1.068	27.83
2	Cln. 2 Tail	1.25	2.75	12.98	0.332	16.94
3	Cln. 1 Tail	5.84	0.24	5.34	0.049	11.69
4	Scav Conc	4.19	0.31	4.96	0.070	11.69
5	Ro Tail	88.07	0.04	13.36	0.009	31.85
1,2,3	Ro Conc	7.74	2.76	81.38	0.181	56.46

These results are compatible with the results of test No. 6FT5 as far as Cu grade and recovery are concerned. The MoS2 recovery was low but this is due in all probability to low collector level, even though it could also be incomplete liberation.

Test No. 14FT9: In an attempt to improve sulphide mineral recovery, a test was conducted using Z-6 (Potassium Amyl Xanthate) as collector. The Z-6 by itself did not appear to give a satisfactory froth using Dowfroth 250 as frother. To improve the float Z-200 was added to the pulp to make it a ratio of two Z-6 to one Z-200. Results were as follows:

Product	Description	Wt. %	Cu %	Cu Distr.	MoS2 %	MoS2 Distr.
	Heads, Chem		0.24		0.028	
	Heads, Calc	100.00	0.26	100.00	0.023	100.00
1	Cln 2 Conc	0.78	21.00	62.84	1.068	35.78
2	Cln 2 Tail	0.33	5.90	7.28	0.759	10.78
3	Cln 1 Tail	2.21	0.75	6.50	0.113	10.78
4.	Scav Conc	5.23	0.47	9.20	0.085	18.96
5	Ro Tail	91.45	0.04	14.18	0.006	23.70
1,2,3	Ro Conc.	3.32	6.02	76.62	0.401	57.34

Examination of the products revealed that the cleaner 2 concentrate was clean but high in pyrite.

Test No. 16FT11: Test No. 16FT11 was also conducted on ore No. 1. For the test the level of reagent was kept the same, but the ratio of Z-6 to Z-200 was one to one, in an attempt to increase Cu selectivity. Also the level of Dowfroth 250 was kept the same. Results were as follows

	Heads, Chem		0.24		0.028	
	Heads, Calc	100.00	0.26	100.00	0.027	100.00
1	Cln 2 Conc	0.75	21.50	62.16	1.184	33.46
2	Cln 2 Tail	0.38	5.25	7.72	0.734	10.53
3	Cln 1 Tail	3.31	0.41	5.41	0.070	8.65
4	Scav Conc	2.74	0.67	6.95	0.190	19.55
5	Ro Tail	92.82	0.05	17.76	0.008	27.81
1,2,3	Ro Conc	4.42	4.39	75.29	0.315	52.64

Results were comparable with those of test No. 16FT11, and not as satisfactory as those of test No. 13FT8.

Test No. 15FT10: Test No. 15FT10 was conducted on ore No. 4 and using the same reagent combination as used for test No. 16FT11. Result were as follows:

	Heads, Chem		0.31		0.021	
	Heads, Calc	100.00	0.36	100.00	0.021	100.00
1	Cln 2 Conc	1.19	18.50	60.44	1.043	59.62
2	Cln 2 Tail	0.69	4.55	8.52	0.337	11.06
3	Cln 1 Tail	3.28	0.47	4.12	0.035	0.96
4	Scav Conc	1.62	0.84	3.85	0.125	10.57
5	Ro Tail	93.22	0.09	23.08	0.004	17.79
1,2,3	Ro Conc	5.16	5.16	73.08	0.289	71.64

Even though the cleaner two concentrate was not as clean as for test No. 16FT11, its pyrite content was much higher than for test No. 6FT5.

These results indicate that additional pyrite depressants should be used along with Z-6 as collector, even in combination with Z-200. Also, the Dowfroth 250 quantity required with the Z-6/Z-200 combination is higher than the quantity required with Z-200 alone.

In conclusion, it appears that the best combination tried to process the Squaw Peak ore is the use of lime as pyrite depressant, and Z-200 as the copper-molybdenum collector for the bulk float; Diesel fuel can be used to improve MoS_2 recovery in the scavenger float and in both floats Dowfroth 250 is an effective frother. H_2SO_4 can be used as pH modifier in the scavenger float.

Detailed laboratory sheets for tests Nos. 6FT5 and 15FT10 Squaw Peak ore No. 4; and tests Nos. 13FT8, 14FT9, and 16FT11 Squaw Peak ore No. 1; are attached to this report.

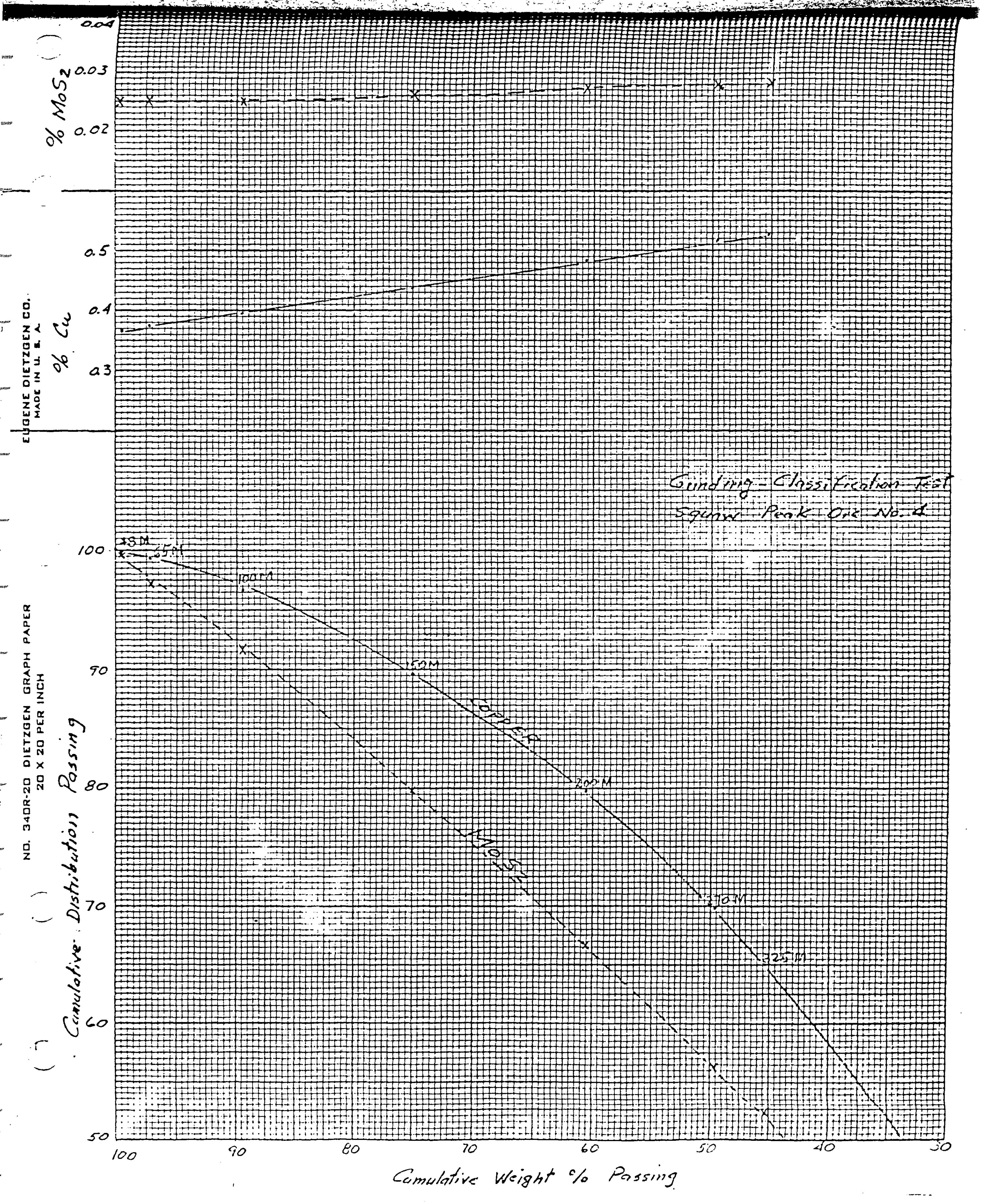
3. A grinding-classification test was conducted on a sample of Squaw Peak Ore No. 4.

   For this test the following points were taken into account:

   a. The copper is present as chalcopyrite, Hardness 3½-4.
   b. The chalcopyrite shows completely liberated particles starting at 48 mesh, and it is a brittle mineral.
   c. Pyrite is present in small amounts. Even though the pyrite is also brittle, it has a hardness of 6-6½.
   d. The main impurities are: quartzite, hardness 7; the feldspars, hardness 6-6½; and the micas. The micas are soft but usually brakes in plates, with one dimension several times the other from a sectional point of view.

   Assuming that the chalcopyrite will be reduced in size faster than any other component of the same size fraction, a sample of minus 10 mesh ore was ground to nominal 48 mesh in one pass. The results were as follows:

Mesh Tyler	Cumulative % Retained: Wt. %	Cu %	Cu Distr.	MoS2 %	MoS2 Distr.
+48	0.38	0.092	0.096	0.018	0.276
+65	2.66	0.086	0.627	0.025	2.679
+100	10.46	0.111	3.188	0.020	8.365
+150	24.95	0.151	10.323	0.020	20.110
+200	39.37	0.187	20.186	0.016	33.550
+270	50.29	0.218	30.046	0.021	43.728
+325	54.60	0.234	34.952	0.022	47.918
-325	45.40	0.523	65.002	0.028	52.082
Heads	100.00	0.366	100.000	0.025	100.000
	Cumulative % Passing				
-48	99.62	0.367	99.904	0.025	99.724
-65	97.34	0.373	99.373	0.025	97.321
-100	89.54	0.395	96.812	0.025	91.632
-150	75.05	0.437	89.677	0.026	79.890
-200	60.63	0.481	79.814	0.027	66.450
-270	49.71	0.514	69.954	0.028	56.272
-325	45.40	0.523	65.002	0.028	52.082



% MoS2
0.04
0.03
0.02
% Cu
0.5
0.4
0.3
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH
Cumulative Distribution Passing
100
90
80
70
60
50
Grinding - Classification Test
Squaw Peak Ore No. 4
35M
65M
100M
150M
COPPER
200M
270M
325M
MoS2
100
90
80
70
60
50
40
30
Cumulative Weight % Passing

What the test tell us is that by differential grinding, we can upgrade the ore from 0.36% Cu to as much as 0.52% Cu, in a product containing 65% of the Cu in the mined ore and 45% of the weight.

One advantage of this system is that we can pick the economical grade of ore to be processed, and store the discard until such a time it becomes economical.

Going back to page 3, a hypothetical case would be as follows:

a. Grinding of the run-of-mine ore to nominal 48 mesh, in open circuit.
b. Classification of the ground ore on 150 mesh.
c. Storage of the plus 150 mesh in a site adjacent to the plant from which it can be pumped back to the plant. Oxidation of the sulphides should not be much of a problem because:
   I. At that mesh size there are mostly middlings, and only part of the sulphide surface will be exposed.
   II. Regrinding of the ore will remove any oxide coating that might form on the surface of the exposed sulphides.
d. For our hypothetical case the material balance would be:
   I. Ore reserves: 30,000,000 tons. 0.36% Cu, 0.025 MoS2.
   II. Mining rate: 5,000TPD, 300 days/year, 20 years.
   III. Plus 150 mesh to storage: 1,250TPD of o.15% Cu and 0.020% MoS2. This represents 10% of the Cu and 20% of the MoS2 in the run-of mine ore.
   IV. Minus 150 to the flotation plant: 3,750TPD of 0.437% Cu and 0.026% MoS2.This represents 90% of the Cu, 80% of the MoS2 and 75% of the tonnage of the run-of-mine ore.
   V. I think that under this circunstances we can expect 85 to 90 percent Cu and MoS2 recovery, and that the milling cost will be reasonable enough to make it attractive at the present prices.
   VI. The system will require much more metallurgical study and very detailed mine planning. However, I feel that we have the tools to do both.

Graph No. 1 illustrates the cumulative % passing figures.

PHILLIPS PETROLEUM COMPANY
Minerals Division

H.A. Franco, P.E.
Metallurgist