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PRELIMINARY REPORT OF INVESTIGATION

FORT HALL MINE

FORT HALL MINING DISTRICT

POCATELLO, IDAHO

February 1963

Ernest E. Burgh
Registered Professional Mining Engineer

CAMERON AND JONES, INCORPORATED

FORT HALL MINE

Introduction

The Fort Hall Mine is located in Bannock County, Idaho near Pocatello and is in the Fort Hall Mining District established in June, 1903. The Fort Hall Mine consists of a tunnel some 4000 feet in length that intersects an ore-bearing vein some 125 feet in width near the terminus of the tunnel. The ore-bearing vein consists of broken and contorted shales with thin-bedded limestones and is in sediments of Ordovician age.

Geology

The general geology of the area is described in Bulletin 370 of the U. S. Geological Survey by Weeks and Heikes, 1907. Generally the ore occurrences in the Fort Hall District are in the conglomerates and shales of Ordovician age. Origin of the ore minerals, primarily copper, is believed to be from a surface flow of diabase of Ordovician age.

Mine Workings

The Fort Hall mine consists of a tunnel driven some 4000 feet in length. Near the tunnel terminus in the

ore-bearing zone, there are some 500 feet of cross-cut, a short raise and a short winse.

The tunnel, about 5 x 7 cross-section, is driven through several sedimentary sections including conglomerates, shales and quartzitic sandstones. The tunnel, driven in the early 1900's, is untimbered except for a few sections through minor fault zones and is in remarkably good condition, indicating good competent rock.

No attempt was made to obtain assay samples of the ore zone but the report prepared by the U. S. Geological Survey and subsequent examinations indicate an average grade near 1.5 percent copper, 1 plus ~~percent~~ oz silver and minor gold values in the 125-foot ore-bearing vein. Several sections within the vein indicate values to 4 and 5 percent copper. The occurrences of copper are of the sulfide variety and indicate the mineral content can be readily recovered and concentrated by modern metallurgical practice.

Conclusions and Recommendations

The preliminary examination of the Fort Hall Mine leaves little doubt of the presence of a copper-silver ore-body of commercial importance. The location of the mine is favorable

from several standpoints, including water and transportation. Underground mining costs will be comparatively low because of the competence of the strata in the tunnel and the width of the ore-bearing vein. Should further reconnaissance establish ore values at surface, low-cost open-pit methods can be employed. Modern metallurgical methods can be used to yield high recovery and concentration.

The following program is recommended for further development:

1. A detailed geologic study to determine ore trends, location of outcrop and favorable areas for exploration.
2. Continuance of the clean-up program in present mine workings including dewatering of winze in the ore zone.
3. Comprehensive sampling of present workings and a drilling and trenching exploration program as outlined by the geologic study.
4. Preliminary metallurgy study of ore-bearing material to determine mill requirements.
5. Evaluation of reserves, mining and metallurgy based on results of recommendations 3 and 4 to determine economics.

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INVESTIGATIONS

O. T. Hansen
Professional Engineer
2301 N. 13th Street -:- Boise, Idaho
Phone 342-7426

Silco Mining Co. Inc.
Route 3
Pocatello, Idaho

GEOLGY

The mineralization of primary exploratory interest is copper with silver and gold being of lesser interest. There are fine seams of copper, in the mineralized area and from the shaft under the #10 drift some area has been stoped sometime in the past to a depth of approximately 30 feet. The present face in the stoped area shows an 18 to 24 inch quartz stringer abundantly mineralized with copper ores. Its total extent is not known, it was observed for about 12 feet verticle.

Observations disclose the most abundant mineralization is present where the host rock has been weakened by faulting and folding. It is in these areas in which the Company plans to explore. The location of the tunnel enhances the possibility of exploration in this mineralized zone either above or below this level. Near the end of the main tunnel is an area which show the most abundant mineralization. There has been no adequate sampling. The 500 foot drift to the south of the main tunnel at a point 3,865 feet from the portal has not been explored and properly examined due to being back filled as for as can be seen and is inaccessible.

A core drilling program should, if properly evaluated , disclose the possible mineral trends much less costly than drifting or shafting. This program would indicate where to do the open work for production.

O. T. Hansen

O. T. Hansen P. E
December 7, 1972

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U. S. MINERAL SURVEY
APPRAISALS
INVESTIGATIONS

O. T. Hansen
Professional Engineer
2301 N. 13th Street -:- Boise, Idaho
Phone 342-7426

GEORGE RAYMOND
323-8913

Observation Report of the Silco Mining Company's
Fort Hall Mine
Fort Hall Mining District, Bannock County, Idaho

Submitted to: Frank Honas, President
Silco Mining Company
Pocatello, Idaho 83201

By: O.T. Hansen, P. E.
2301 North 13th Street
Boise, Idaho 83702

INTRODUCTION:

The Fort Hall Mining district was established in June, 1902. Not long after, the Fort Hall Indian Reservation, lying within Bannock County, was opened to entry of agricultural and mining claimants.

The Fort Hall Mining Company was one of the first to start mining on their property. And, by 1916 the present tunnels, raises and shafts were about completed. Only sporatic work has been done since that time. I do not have any personal knowledge of this work. However, I do know about the by-pass drift (around the "caved" area in the No. 10 tunnel), which was made by the present company.

LOCATION

The Fort Hall Mine lies about 7 miles southeast of Pocatello, Idaho in sections 34 and 35, T. 7 S., R. 35 E., B.M., on the west side of the Bannock Mountain Range.

DEVELOPMENT:

This mine was being developed from 1902 through 1916. During This period of time, a long tunnel--4300 ft., was driven east into the mountain with raises, drifts and shafts. The latter were not accessible at the time of my visits to the property. However, the long tunnel was open and rehabilitated, so it was possible to go to the end. The old raises had lost their timber and all the shafts or winzes, which were sunk from this level, were full of water.

The No. 9 drift, to the right approximately 3900 ft. from the main tunnel portal, is full of rock and was not accessible. This drift is not "caved", but has been filled with muck to save the haulage to the surface.

The No. 10 drift, to the left near the face of the tunnel, was badly "caved". Silco Mining Company has driven a drift around this "cave" and intersected the continuation of the No. 10 drift about 200 ft. from the main tunnel and had cleaned some of the No. 10 beyond the the "cave".

PRESENT PLANT FACILITIES:

The present company has equipment for a small operation, which includes a compressor, light plant, trammers, cars, and living quarters. The main tunnel has track and an air line to the No. 9 drift. I understand that this is unencumbered and is fully owned by the company. The facilities are sufficient for the present prospecting development, though it would be desirable to make additions.

GEOLOGY:

During my short visit to the mine, I observed the rock encountered as we went into the mine. All of the rock penetrated was of sedimentary type--ranging from conglomerates through quartzites, shale, slate, dolomite,

sandstone, and calcareous shales. The age of which has not been determined. Weeks and Heikes, in the U. S. Geological Survey Bulletin No. 340, page 177[1], places the age (of the rocks) in the Ordovician rocks of the Paleozoic era. More recent writer have questioned this and place the Bannock Range in the pre-Paleozoic.

At no place did I see rock of igneous origin.

MINERALIZATION:

One can see copper stains and little seams and veinlets of mineral in many places throughout the tunnel. Most of the copper, however, is in the sulphide-chalcopyrite. The area, which has shown the most abundant mineralization, is near the end of the main tunnel and had been prospected mostly by the original company. This zone of mineralization is approximately 125 ft. wide--striking generally North-South and dipping East. The zone is in highly contorted and folded calcareous shales with some inter-bedding of siliceous limestones.

The minerals occur in fine seams and has been deposited in bedding planes and fractures. The whole mass is more or less mineralized, but there is no strong vein present. I took no samples, as it was reported in U.S.G.S. Bulletin 340[2], that the samples would run 1 to 1 1/2 % in copper, 1/2 ounce in silver and a trace of gold. No other values have been reported in the literature.

Like most copper ores, a small amount shows strong and gives a false impression as to its volume within the host rock.

There doesn't seem to be a deposition between the two marked rock-types, but rather a deposition of minerals from water solution

---

[1]Weeks, F. B. and Heikes, V. C., Notes on the Fort Hall Mining District, Idaho: U. S. Geological Survey Bulletin 340, 1908.

[2]Obid

because of the presence of fractures to admit the solution and enough neutralizer to make them drop their load.

Weeks and Heikes[a] attributes mineralization to a igneous diabase which "intercalated in the sediments" below the mineralized zone".

No other mineralizing has been found nor reported in the present open development.

PRODUCTION:

For the amount of work done on this property, only a meager amount has been produced, and we do not have any record of what it brought in returns. However, in my research for the amount of ore produced from this property, in official publications, there seems to have been but 2 cars or approximately 100 tons. The last record of production was in 1916, according to the U.. S. Geological Survey Bulletin No. 713[2] It was reported that an additional 3 cars of ore was produced in 1917-18. But, this did not get into the record nor has one been found to exist.

RECOMMENDATIONS:

The following is recommended for further development of this property.

1. Detailed survey and maps prepared of both underground and surface, so that correlation can be made of all the features.
2. A drilling program both surface and underground.
3. According to Weeks and Heikes , there is a vertical distance from the surface mineral showing of approximately 800 ft. and on a dip of about 1200 ft. from present tunnel level.

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[a]Weeks, F. B. and Heikes, V. C. work cited, pp. 175-183.

2 Mansfield, G. R., Geography, Geology, and Mineral Resources of the Fort Hall Indian Reservation: U. S. Geological Survey Bulletin 713, 1920

4. Studies be made of the possibilities of an open-pit or block cave-ing methods for the recovery of the low-grade mineralization which is present.

5. That drift No. 9 be cleaned-out, as it is "back-fill" and not "caved" material; then this can be studied.

6. Clean the main tunnel to its face.

7. That developments below the tunnel level be from shaft instead of inclined tunnel. This would make it possible to go deeper if the ore justifies it.

8. Bring in electric power.

9. Install forced-air ventilation--preferably fan and air ducts.

10. That all drilling, mapping, development plans be under the direction of personnel trained in mine development; for the protection of the public, a licensed mining engineer in the State of Idaho.

These recommendations are not listed in the order of accomplishments. Many can be done concurrently.

SUMMARY:

This is not a mine ready for production. It is a prospect showing mineralization which has been abandoned by others as uneconomic. There is a sizeable amount of usable opening already done which places the present owners with a favorable spot for further prospecting and development. New mining techniques and equipment may be able to bring this to fruition. The former Operators could not continue as the returns did not equal the cost. No evidence of an extensive high-grade ore body was observed, and the possibility of one existing is not likely.

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[1]Obid

The cost to search for small "pods" of high-grade ore may be prohibitive. The search should be made to attempt to develope large tonnage of possible low-grade ore, which cannot definitely be known or stated. In this way, an operative mine might be more assured.

O.T. Hansen

O.T. Hansen, P. E.

DATED This 15 of January, 1970.

REGISTERED PROFESSIONAL ENGINEER
630
STATE OF IDAHO
O.T. HANSEN

SILCO MINING CO., INC.

ROUTE 1 SOUTH - BOX 365 - PHONE 233-4240
POCATELLO, IDAHO 83201

February 9, 1973

Essex International
Mr. John Wilson, Geogolist
P.O. Box 888
Milford, Utah

Dear Mr. Wilson;

Enclosed is some information and geology reports concerning our property. I am sorry I do not have more to send you as Mr. Hansen has most all of the information in his possession. But I will give you all I have. I was instructed to send this information to you.

We have 13 unpatented claims, 7 miles southeast of Pocatello, 1½ miles from a paved road, 2 miles from the railroad and freeway, and 1½ miles from electric power. Elevation of mine portal is 5280 feet.

We are contemplating a $150,000.00 regulation A offering. Mr. Hansen's report and the supplementary one has already been approved by the Securities and Exchange Commission. This would be mostly for a core drilling program.

Mr. Edward H. Snyder, International Smelter, suggested, I contact Essex International. After reading the information I sent you, and you are further interested, prehaps you would be interested in paying us a visit. If so please contact me as I will need about a week to get everything ready. I brought the light plant down and repaired it, but haven't got it back yet, as the snow is about 2 feet deep on the road. I look for improvements in a few weeks. I need the light plant to run the rectifier to charge the battery for the trammer. Also the tunnel needs to be aired for about 3 days. We stopped activities during the winter.

Mr. Hansen is our consultant, I hope his and Ernest Burghs report will give you sufficient information necessary to interest you to examine our property.

I am sure Mr. Hansen wouldn't mind talking to you concerning our property should you feel it is necessary at this time.

Very truly yours,

Frank L. Honas

Frank L. Honas, President

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O. T. Hansen
Professional Engineer
2301 N. 13th Street -:- Boise, Idaho
Phone 342-7426

December 7, 1972

Silco Mining Co. Inc.
Frank Honas President
Route #3 South
Pocateelo, Idaho 83201

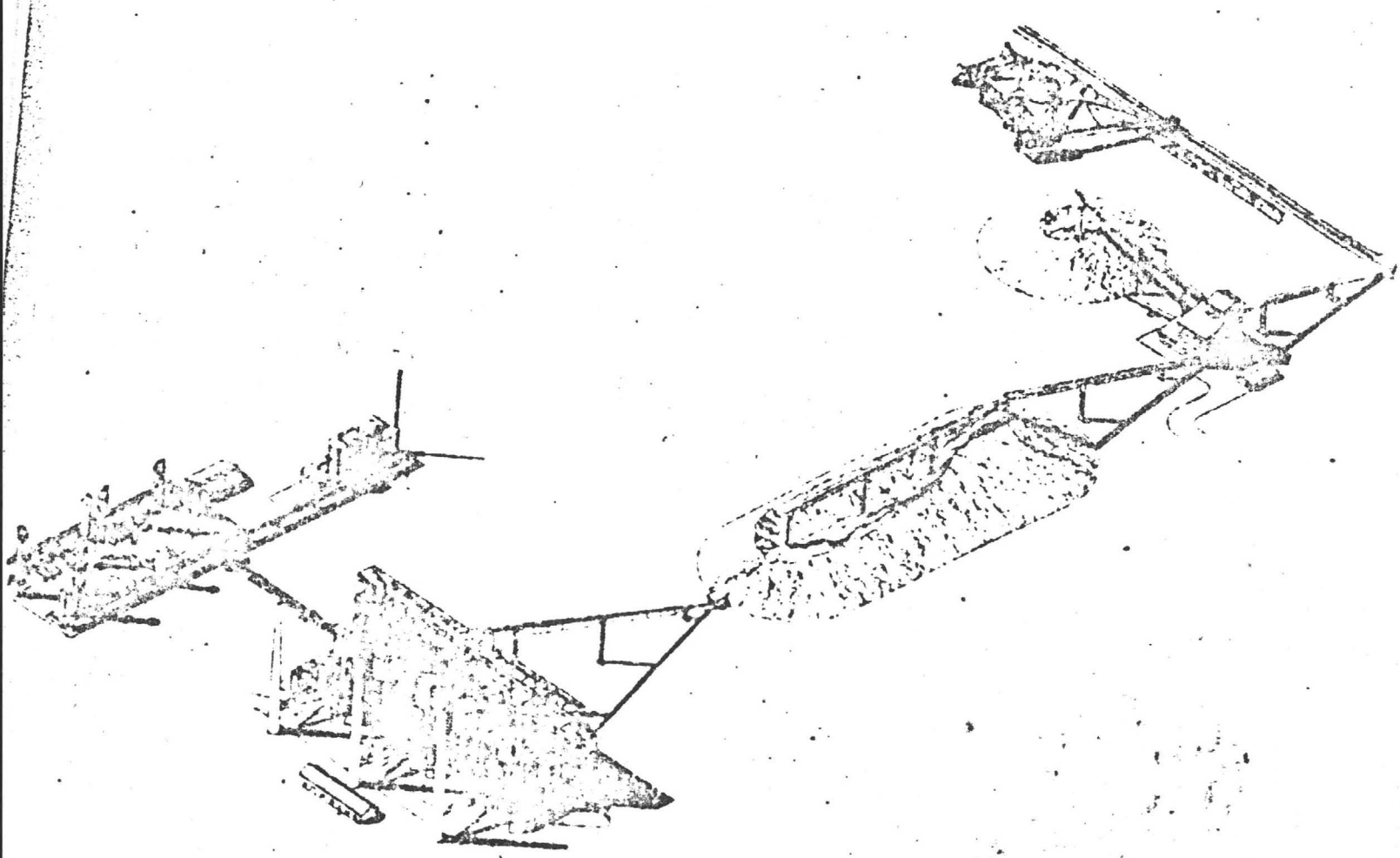
Dear Mr. Honas;

Here is the long delayed rewrite of the Geology section of your propectus. I sure regret the delay but trust it will fill your needs.

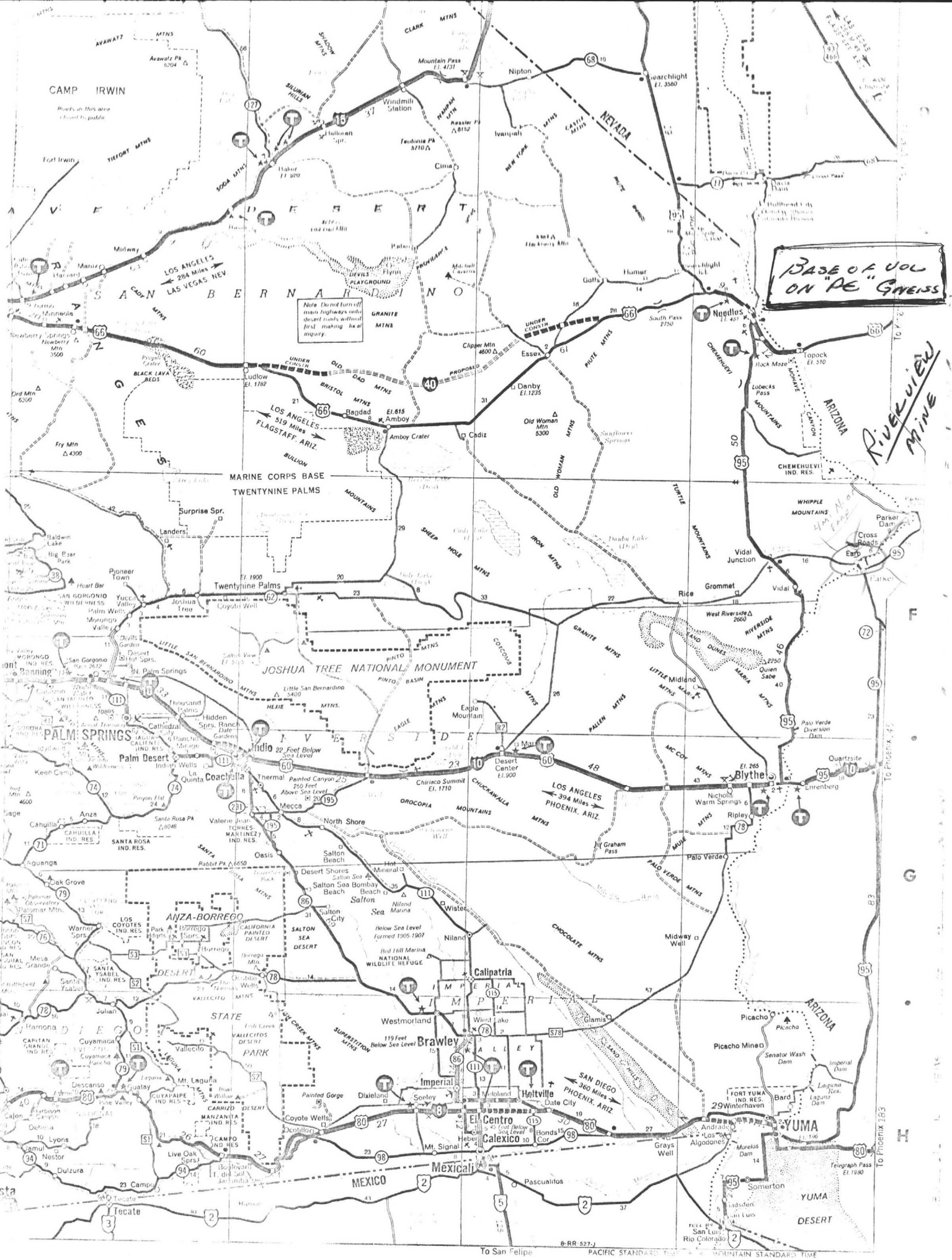
I seem to lack time to get all the work done for which I commit myself.

I have put in a punch for a drilling program. This I feel is a must. The purchase of a drill and the training of an operator may pay off in custom work when it is not busy at the property.

Sincerely,
O. T. Hansen
O. T. Hansen P. E.



CAMERON AND JONES
ENGINEERS–CONSULTANTS
2150 SO. DELLAIRE ST. DENVER 22, COLO.


BASE OF VOL ON "PE" GNEISS
RIVERVIEW MINE
CAMP IRWIN
Roads in this area closed to public
NEVADA
ARIZONA
SAN BERNARDINO
MARINE CORPS BASE
TWENTYNINE PALMS
JOSHUA TREE NATIONAL MONUMENT
PALM SPRINGS
Indio
Coachella
Blythe
Brawley
Calipatria
Imperial
El Centro
Calexico
Holtville
YUMA
Mexicali
MEXICO
Tecate
Needles
Barstow
Amboy
Ludlow
Bagdad
Essex
Danby
Cadiz
Twentynine Palms
Joshua Tree
Landers
Desert Center
Chiriaco Summit
Mecca
Thermal
Niland
Salton Sea
Westmorland
Palo Verde
Ripley
Vidal
Parker
LOS ANGELES 284 Miles LAS VEGAS NEV
LOS ANGELES 519 Miles FLAGSTAFF, ARIZ.
LOS ANGELES 394 Miles PHOENIX, ARIZ.
SAN DIEGO 360 Miles PHOENIX, ARIZ.
To San Felipe
To Phoenix 183
PACIFIC STANDARD TIME
MOUNTAIN STANDARD TIME
8-RR-527-J

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PRELIMINARY REPORT OF INVESTIGATION

FORT HALL MINE

FORT HALL MINING DISTRICT

POCATELLO, IDAHO

February 1963

Ernest E. Burgh
Registered Professional Mining Engineer

FORT HALL MINE

Introduction

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The following program is recommended for further development:

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GEORGE ... MOND
323-8913

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Fort Hall Mine
Fort Hall Mining District, Bannock County, Idaho

Submitted to: Frank Honas, President
Silco Mining Company
Pocatello, Idaho 83201

By: O.T. Hansen, P. E.
2301 North 13th Street
Boise, Idaho 83702

INTRODUCTION:

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This mine was being developed from 1902 through 1916. During This period of time, a long tunnel--4300 ft., was driven east into the mountain with raises, drifts and shafts. The latter were not accessible at the time of my visits to the property. However, the long tunnel was open and rehabilitated, so it was possible to go to the end. The old raises had lost their timber and all the shafts or winzes, which were sunk from this level, were full of water.

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At no place did I see rock of igneous origin.

MINERALIZATION:

One can see copper stains and little seams and veinlets of mineral in many places throughout the tunnel. Most of the copper, however, is in the sulphide-chalcopyrite. The area, which has shown the most abundant mineralization, is near the end of the main tunnel and had been prospected mostly by the original company. This zone of mineralization is approximately 125 ft. wide--striking generally North-South and dipping East. The zone is in highly contorted and folded calcareous shales with some inter-bedding of siliceous limestones.

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RECOMMENDATIONS:

The following is recommended for further development of this property.

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2. A drilling program both surface and underground.
3. According to Weeks and Heikes , there is a vertical distance from the surface mineral showing of approximately 800 ft. and on a dip of about 1200 ft. from present tunnel level.

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2 Mansfield, G. R., Geography, Geology, and Mineral Resources of the Fort Hall Indian Reservation: U. S. Geological Survey Bulletin 713, 1920

4. Studies be made of the possibilities of an open-pit or block cave-ing methods for the recovery of the low-grade mineralization which is present.

5. That drift No. 9 be cleaned-out, as it is "back-fill" and not "caved" material; then this can be studied.

6. Clean the main tunnel to its face.

7. That developments below the tunnel level be from shaft instead of inclined tunnel. This would make it possible to go deeper if the ore justifies it.

8. Bring in electric power.

9. Install forced-air ventilation--preferably fan and air ducts.

10. That all drilling, mapping, development plans be under the direction of personnel trained in mine development; for the protection of the public, a licensed mining engineer in the State of Idaho.

These recommendations are not listed in the order of accomplishments. Many can be done concurrently.

SUMMARY:

This is not a mine ready for production. It is a prospect showing mineralization which has been abandoned by others as uneconomic. There is a sizeable amount of usable opening already done which places the present owners with a favorable spot for further prospecting and development. New mining techniques and equipment may be able to bring this to fruition. The former Operators could not continue as the returns did not equal the cost. No evidence of an extensive high-grade ore body was observed, and the possibility of one existing is not likely.

---

[1]Obid

The cost to search for small "pods" of high-grade ore may be prohibitive. The search should be made to attempt to develope large tonnage of possible low-grade ore, which cannot definitely be known or stated. In this way, an operative mine might be more assured.

O.T. Hansen

O.T. Hansen, P. E.

DATED This 15 of January, 1970.

REGISTERED PROFESSIONAL ENGINEER
630
STATE OF IDAHO
O. T. HANSEN

CIVIL
LAND SURVEY
GEOLOGIST
REPORTS

MINING
U. S. MINERAL SURVEY
APPRAISALS
INVESTIGATIONS

O. T. Hansen
Professional Engineer
2301 N. 13th Street -:- Boise, Idaho
Phone 342-7426

December 7, 1972

Silco Mining Co. Inc.
Frank Honas President
Route #3 South
Pocateelo, Idaho 83201

Dear Mr. Honas;

Here is the long delayed rewrite of the Geology section of your propectus. I sure regret the delay but trust it will fill your needs.

I seem to lack time to get all the work done for which I commit myself.

I have put in a punch for a drilling program. This I feel is a must. The purchase of a drill and the training of an operator may pay off in custom work when it is not busy at the property.

Sincerely,
O. T. Hansen
O. T. Hansen P. E.

H. Lanier — Ft. Wayne, Ind.

P. Eimon — Tucson, Ariz.

Earth Resources Mining Division — Feb. 6, 1974

The validity of ore reserves reported by Earth Resources Company at the Nacimiento copper mine and at the partly owned silver prospect in Idaho is difficult to evaluate from the data made available.

If Essex is interested in acquiring a 3,000 ton plus per day copper mining operation with a probable five year ore reserve, a six month option with no front end payment will be necessary in order to provide time for evaluation of ore reserves. An appropriation for substantial amounts of drilling by Essex to confirm and attempt to expand ore reserves probably will be needed during the option period.

PIE:td

X-258-FWP

EXPENSE REPORT

NAME Bob Helming

Week Ending Feb 9, 1974

Approved By E. Franklin

ITEMS	SUN	MON 4	TUES 5	WED	THURS	FRI	SAT	TOTAL
Breakfast								
Lunch								
Dinner								
*Hotel								
*Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage								
Cabs or Local Transportation								
*Transportation (Itemize)		18 00						
Personal Car - Write mileage below								
*Company Car Expense		6 15	103 68					
Entertainment Expense								
Business Meals								
Tips								
DAILY TOTALS		24 15	103 68					127.83
Mileage Company Car Start		Finish						
Mileage Personal Car (Show Daily)								

EXPLANATIONS

Monday

#6 15 gas purchase in Tucson where I attended one day exploration meeting on 2/1/74

#18 00 reconnaissance plane trip around Safford area 1/26/74

Tuesday

#103.68 paid service station account for January 1974

#53.28 gas for surveyor's rental truck

#50.40 gas & service on vehicle assigned to Safford License 2HJ-656 Az.

Wednesday

Thursday

Friday

Saturday

Dick Kelly

Ken Jones

Tucson Office -
New Truck Order

Ft. Wayne, Ind.

Tucson, Ariz.

Feb. 7, 1974

Tires on the company Bronco that will be replaced by one of new vehicles recently requested are getting thin and would normally be replaced at this time. But, if the new vehicle request is going to be approved we would like to avoid, if possible, the expense for tires and other needed repairs.

Please let us know as soon as you have any response on the request for new vehicles for the Tucson office.

JKJ:td

ACP-005

EXPENSE REPORT

NAME William G. Brown Week Ending 2-2-74 Approved By Paul Ewing

ITEMS	SUN	MON	TUES 1-29	WED 1-30	THURS 1-31	FRI 2-1	SAT 2-2	TOTAL
Breakfast				1 98	1 90			
Lunch			2 95	2 93	2 87			
Dinner			5 52	4 75				
*Hotel			12 48	12 48				
*Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage								
Cabs or Local Transportation								
*Transportation (Itemize)								
Personal Car - Write mileage below								
*Company Car Expense			3 01					
Entertainment Expense								
Business Meals								
Tips								
DAILY TOTALS			25 96	22 14	4 77			$52.87
Mileage Company Car Start		Finish						
Mileage Personal Car (Show Daily)								

EXPLANATIONS

Monday

TUCSON OFFICE

Tuesday

LEFT FOR PATAGONIA, ARIZ.
TAKING GEO. CHEM SAMPLES
ON 200' GRID ON WORLDS FAIR

Wednesday

PATAGONIA, ARIZ
TAKING GEO. CHEM SAMPLES
ON 200' GRID

Thursday

PATAGONIA, ARIZ
TAKING GEO-CHEM SAMPLES
ON 200' GRID
LEFT FOR TUCSON

Friday

TUCSON OFFICE

Saturday

ACT 40

EXPENSE REPORT

NAME Lyall J. Lichty. Week Ending June 16/74 Approved By Paul Ennis

ITEMS	SUN 20	MON 21	TUES 22	WED 23	THURS 24	FRI 25	SAT 26	TOTAL
Breakfast								
Lunch								
Dinner								
*Hotel								
*Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage PARKING			60	60				
Cabs or Local Transportation								
								1.20
*Transportation (Itemize)								
Personal Car - Write mileage below		42 00						42.00
*Company Car Expense								
Entertainment Expense								
Business Meals		7 98						7 98
Tips		1 00						1.00
DAILY TOTALS		50.98	60	60				52.18
Mileage Company Car Start		Finish						
Mileage Personal Car (Show Daily)		280						280

EXPLANATIONS

Monday

Drove Leo Smith to hearing in Sayford concerning litigation by Prof. C. drill cores. At lunch with Helming continued discussion on cores and their storage

Tuesday

To Leo Smith's office

Wednesday

To Leo Smith's office

Thursday

Friday

Saturday

X-258-FWP

EXPENSE REPORT

NAME [illegible] Week Ending 2-2-74 Approved By Paul Ewing

ITEMS	SUN	MON	TUES	WED	THURS	FRI	SAT	TOTAL
Breakfast			1 97	1 97	1 52	1 97		
Lunch		3 31	1 48	2 00	2 00	2 56		
Dinner		3 73	3 02	5 78	3 37			
*Hotel		14 56	14 56	14 56	14 56			
*Other Expenses (Itemize)								
Telephone & Telegraph				7 37				
Tips								
Toll Charges								
Baggage or Storage								
Cabs or Local Transportation								
*Transportation (Itemize)								
Truck Rental Mon. thru Friday						89 00		
Personal Car - Write mileage below								
*Company Car Expense								
Entertainment Expense								
Business Meals								
Tips								
DAILY TOTALS		21 60	22 03	29 76	21 45	93 53		188.37
Mileage Company Car Start		Finish						
Mileage Personal Car (Show Daily)								

EXPLANATIONS

Monday

Tuesday

Shafford Surveying

Wednesday

Thursday

Friday

Saturday

ACT-005

EXPENSE REPORT

NAME Paul Eimon

Week Ending 2/2/74

Approved By

ITEMS	SUN 27 (January)	MON 28	TUES 29	WED 30	THURS 31	FRI 1 (February)	SAT 2	TOTAL
Breakfast				1 74				
Lunch				—		24 30		
Dinner			2 10					
*Hotel			14 56					
*Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage								
Cabs or Local Transportation								
*Transportation (Itemize)								
Personal Car - Write mileage below			19 05	19 50				
*Company Car Expense								
Entertainment Expense								
Business Meals								
Tips								
DAILY TOTALS			35 91	21 24		24 30		81.25
Mileage Company Car Start / Finish								
Mileage Personal Car (Show Daily)			127	130				

EXPLANATIONS

Monday
Tucson
General

Tuesday
Tucson
World's Fair
Safford > Review
General
Tucson / Safford

Wednesday
Safford
Geologic Discussions
Drive to PMC property
Meeting at Phelps Dodge Min
Visit to Guy Anderson
Safford / Tucson

Thursday
Tucson
General

Friday
Tucson
Exploration Staff Meeting All Day
Lunch - Staff - Mining Club of the Southwest
Ken Jones, Grover Heinrichs, Lyall Lichty, P. Eimon, Bob Helming, Bill Brown, Bud Temple

Saturday
Tucson
Calls on Safford lawsuit

ACT-005

EXPENSE REPORT

NAME B. P. Bellum

Week Ending 2/1/74

Approved By Paul Cuin

ITEMS	SUN	MON	TUES	WED	THURS	FRI	SAT	TOTAL
Breakfast					2 10	1 95		
Lunch					2 20	2 80		
Dinner						8 20		
Hotel					8 48			
Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage • Parking						3 00		
Cabs or Local Transportation								
Transportation (Itemize)								
Airline ticket (Cash)					140 55			
Car rental						116 82		
Personal Car - Write mileage below					1 95	1 95		
Company Car Expense								
Entertainment Expense								
Business Meals								
Tips								
DAILY TOTALS					155 28	134 72		290.00
Mileage Company Car Start		Finish						
Mileage Personal Car (Show Daily)					13	13		

EXPLANATIONS

Monday

Earth Resources Report

Thursday

Milford Utah to review cost and production data with H. Lanier

Tuesday

Earth Resources Report

Friday

Milford Utah

Wednesday

Earth Resources Report

Saturday

ACT-005

EXPENSE REPORT

NAME LYALL J. LICHTY

Week Ending Feb 2/74

Approved By Paul Ennis

ITEMS	SUN 27	MON 28	TUES 29	WED 30	THURS 31	FRI 1	SAT 2	TOTAL
Breakfast								
Lunch								
Dinner								
*Hotel								
*Other Expenses (Itemize)								
Telephone & Telegraph								
Tips								
Toll Charges								
Baggage or Storage PARKING			80			80		
Cabs or Local Transportation								
								1.60
*Transportation (Itemize)								
Personal Car - Write mileage below		38.10		8.10				46.20
*Company Car Expense								
Entertainment Expense								
Business Meals				6.23				6.23
Tips								
DAILY TOTALS		38.10	80	14.33		80		54.03
Mileage Company Car Start / Finish								
Mileage Personal Car (Show Daily)		254		54				308

EXPLANATIONS

Monday

Drove to Phoenix to investigate Diversified Metal Plant

Tuesday

To Leo Smith's office

Wednesday

To Mountain States office to confer with Bhappu + Fisher re litigation and to see the exhibits being prepared. Continued discussion at lunch

Thursday

Friday

To Leo Smith's office for discussion of Clyde Osborne's deposition

Saturday

Marubeni Perú S. A.

Takes the pleasure in advising you that from this date our new address is as follows:

Las Begonias No. 441 - 9th. Floor,
San Isidro, Lima 27, Perú
Central Telephone No. 40-3347
P.O. Box 4126
Cable Address: MARUBENI LIMA
Telex: Nos. 3540052 and PX5433

You can rest assured that the staff of Marubeni Perú S. A. will continue serving you as in the past and will be pleased to assist you in whatever way possible.
Thanking you for your kind cooperation and looking forward to receiving further orders from you, we remain.

Yours faithfully,

Lima, Perú, 28th January 1974.

TUCSON DAILY CITIZEN

THURSDAY, FEBRUARY 7, 1974

the summer TG&E

2-2-05-36

Paul Emmons

Tucson

Essex/NPI Polyurethane indoor signs

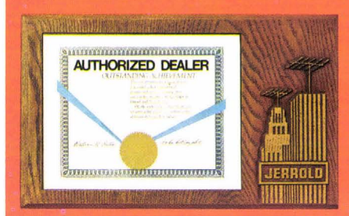
***Add dimension to your sales** with this modern concept in functional P-O-P design. Any size, shape, color and simulated texture is possible—illuminated or non-illuminated—in lightweight, durable polyurethane construction. Signs can be custom-made or utilize the standard Mark II model. And they can include clocks, motion, transparencies. So for a quality image and maximum visual impact at minimum cost, consider Essex/NPI polyurethane indoor signs!*

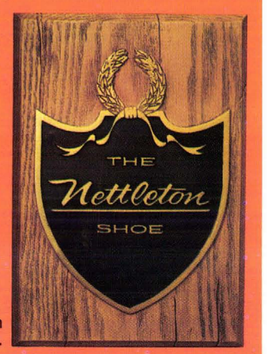
10″ draught beer tap handle for Guinnes.

Distinctive tap handle with marble-like inset for Bass.

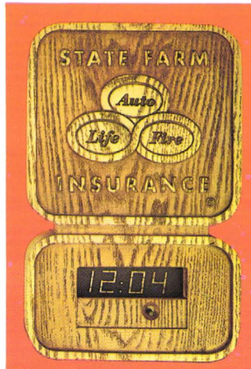
Custom molded tap handle in wood-grain for Harp Lager.

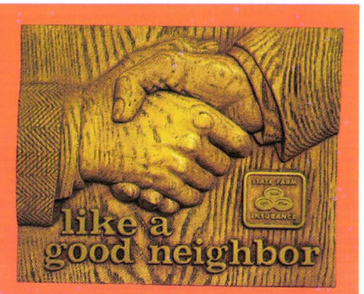
Certificate holder developed for Jerrold Electric is 16″ x 10″.





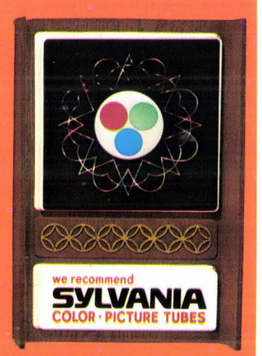
14″ x 9½″ dealer plaque sign used by Nettleton Shoes.

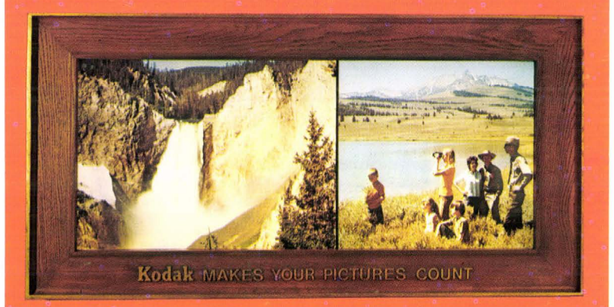




State Farm Insurance ordered these two: a 16″ x 10″ digital clock with logo; and an 11″ x 10″ agent wall sign.

Sylvania's 16″ x 7″ in-store clock sign and a 14″ x 21″ Sylvania illuminated motion sign for dealers.





Eastman Kodak is using this 53″ x 27″ wood-grain photo display unit at point-of-purchase.

ESSEX illuminated signs | NPI

ESSEX INTERNATIONAL, INC.
NPI / ILLUMINATED SIGNS
NEON AVENUE, LIMA, OHIO 45801

HOME OFFICE: Lima (419) 223-9045—REPRESENTATIVES: Chicago 539-2000—Cleveland (Medina) 725-5922—Dallas 352-4431
Detroit 675-4634—Kansas City (Mo.) 421-3455—Louisville (Ky.) 584-5368—Milwaukee 352-9009—Minneapolis 339-7238
New York 751-3185—Philadelphia (Willow Grove) 659-1721—Seattle 623-5432—St. Louis (Florissant) 831-6222

RECEIVED
JAN 29 1973

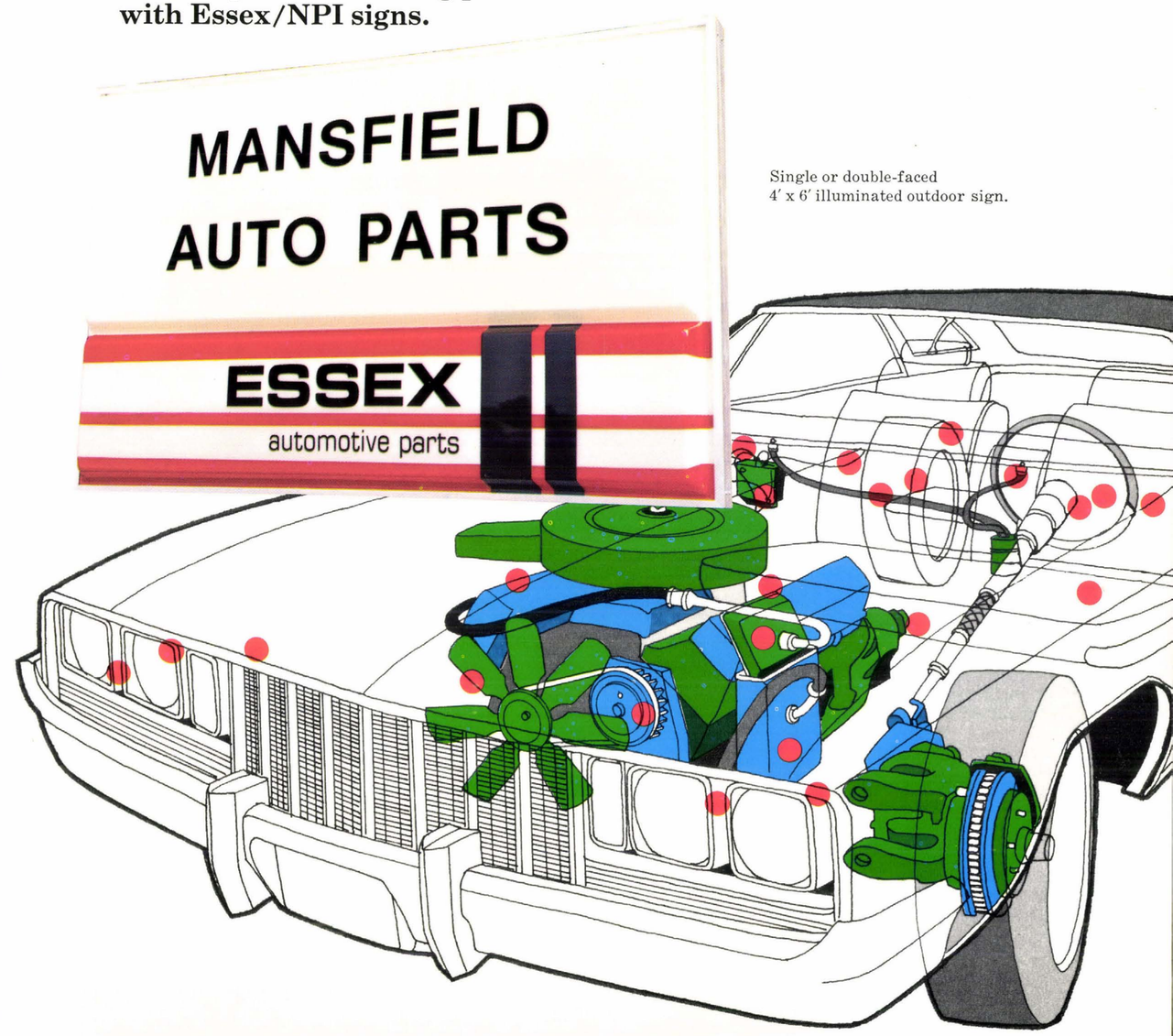
volume 3, number 9

SIGNAGE

ESSEX illuminated signs | NPI

ESSEX INTERNATIONAL, INC.
NPI / ILLUMINATED SIGNS

Essex Automotive Division revs up its auto parts marketing plan with Essex/NPI signs.



Single or double-faced 4′ x 6′ illuminated outdoor sign.

Jobbers get a sales boost from their day-in, day-out advertisement on a 4′ x 6′ outdoor sign.

Sales accelerate for Essex auto replacement parts . . . and Essex/NPI signs help spread the word.

Essex International Inc. has been a major automotive electrical parts supplier to original equipment manufacturers and independent brand marketers since 1929.

But in 1967 they decided to enter the market under their own name . . . Essex Automotive Parts. And they decided to work through the traditional channels—through warehouse distributors to automotive jobbers to independent repair garages, dealers and service stations.

In 1968 they had two salesmen and one account in Ohio.

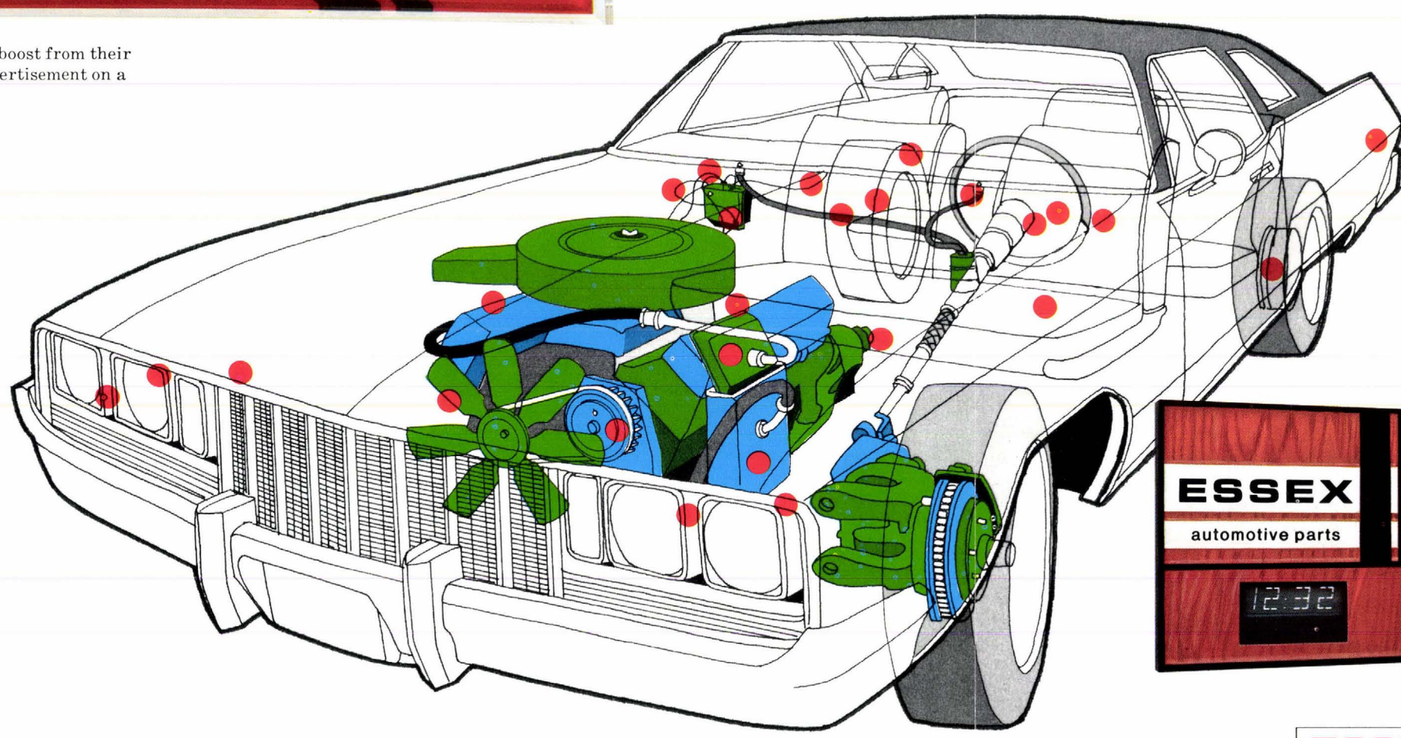
Today, they have 59 salesmen and over 350 Warehouse Distributors selling Essex parts in 49 states.

And Essex/NPI signs light the way to even greater brand recognition.

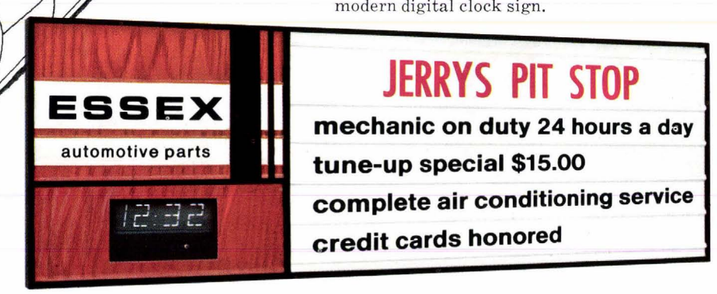
Automotive jobbers promote themselves and the name of their products to the vast passing public with a colorful illuminated outdoor sign . . . a sign that lets them "sell" 24 hours a day.

Independent repair garages, service stations and dealers promote Essex auto parts, the time and their services from a highly flexible 12″ x 37″ illuminated indoor sign with a G.E. Telechron digital clock. A 25″ x 12″ area permits the simple use of any message the dealer wishes to pass on to his customers. The unit may be wall or window mounted, and also serves as an in-store night light.

Essex can look for their auto parts sales to continue zooming . . . with a little help from Essex/NPI's tireless 24-hour-a-day "silent salesmen."



Dealers remind customers that it's time to buy Essex with this modular-message, modern digital clock sign.



ESSEX illuminated signs | NPI

ESSEX INTERNATIONAL, INC.
NPI / ILLUMINATED SIGNS
NEON AVENUE, LIMA, OHIO 45801

HOME OFFICE: Lima (419) 223-9045—REPRESENTATIVES: Chicago 539-2000—Cleveland (Medina) 725-5922—Dallas 352-4431
Detroit 675-4634—Kansas City (Mo.) 421-3455—Louisville (Ky.) 584-5368—Milwaukee 352-9009—Minneapolis 339-7238
New York 751-3185—Philadelphia (Willow Grove) 659-1721—Seattle 623-5432—St. Louis (Florissant) 831-6222

Trademark registered U.S.A. and Canada Litho in U.S.A. 11/73

Howard Lanier — Ft. Wayne, Ind.

Paul Eimon — Tucson, Ariz.

Mineral Deposits in People's Republic of China — Feb. 5, 1974

I asked Ken to report this interesting bit of data because I noticed recently in the National Observer magazine that United Aircraft was negotiating the sale of helicopters to China. This bit of data might be useful in developing commercial interchange with China. I personally very much doubt if the Chinese would be aware of the porphyry copper potential in the geologic environment that is described.

PIE:td
attachment

AC-016

avoid verbal orders

avo

TO Paul Eimon LOCATION Tucson, Ariz.

FROM Ken Jones LOCATION " "

SUBJ. Mineral Deposits in People's Republic of China DATE Feb. 5, 1974

COPY TO

In reviewing a 1921 publication entitled "Silver Ores" by the Imperial Institute of London I noted the following reference on Silver deposits of China.

> "In the Hunan province, Central China, is the Shin-Ko-Shan zinc and lead mine. The country is limestone (probably carboniferous) overlaid by red sandstones and shales of Cretaceous or Tertiary age. Large irregular-shaped bodies of ore, composed of blende and galena with pyrite and chalcopyrite, are developed in the limestone at and near its contact with syenite. The latter has small crystals of chalcopyrite disseminated through it....."

Although this is a very brief description it certainly has the earmarks of a porphyry copper deposit. The CIA Atlas on the People's Republic of Chiba does not show a copper deposit in the Hunan Province, so the possibility exists that undeveloped porphyry copper deposits are present in China.

JKJ:td Ken

Howard Lanier Ft. Wayne, Ind.

Paul Eimon Tucson, Ariz.

Annual Reports Feb. 5, 1974

As per discussions and instructions from Don Bellum, we have decided that we could use about 400 copies of the 1973 Essex-United Aircraft report to be mailed to this address.

PIE:td

GEOLOGIC CHARACTERISTICS OF 26 MAJOR PORPHYRY COPPER AND MOLYBDENUM DEPOSITS

by

J. David Lowell and John M. Guilbert

Deposit

Deposit (Column 1)

The foldout Table 1 permits comparison of relevant geologic detail of 26 porphyry copper and porphyry molbdenum ore deposits in the New World. Data were collected for as many deposits as possible, omitting only those deposits for which modern descriptions have not been published or those which have been discovered so recently that descriptions are not yet in print. For obvious reasons, greater attention has generally been paid to North American deposits. The table has been kept as factual and as true to the published descriptions as possible, although careful interpretation was sometimes required simply in the selection of the appropriate column in which to enter information. Factual information, generally known but not necessarily in print, is also judiciously included. Entries for most of the deposits have been checked and verified by the geologists and authors most familiar with them. Abbreviations used in the table are given on the page opposite the foldout.

Preore Host Rock

Preore Host Rock (Column 2)

This column cites rock types and ages into which the igneous host rocks of the respective deposits have been intruded. Mineralization may occur in these preore rocks, as at Bingham and Safford, or the preore host

rocks may be too remote, at least laterally as at Butte. An appraisal of the the local economic importance of preore rocks is given in Columns 14 and 15 under "Orebody." It is apparent from Column 2 that the porphyry deposit host rocks are emplaced generally high in the geologic column. Of the 25 deposits for which preore host rock ages are available, 9 have penetrated into late Cretaceous preore materials, another 5 are in older Mesozoic sections, 4 are in Paleozoic rocks, and 7 occur in Precambrian rocks only. In several of these latter deposits, younger sections of the geologic column can be projected over the present exposures of mineralized intrusive rock without adding more than a few thousand feet of cover. It is implicit that most of the porphyry deposits formed within a few thousand feet of the surface, many perhaps less than a mile from the surface.

Igneous Host Rock

Name and Age (Columns 3 and 4)

The third major portion of Table 1 describes the igneous rocks in which and with which the porphyry deposits occur. The names of Column 3 apply to the intrusive units of most intimate association with the orebodies in both space and time. Ages cited in Column 4 generally apply to the intrusive host rocks themselves rather than to the ore deposits associated with them, but several considerations indicate that ore deposition was essentially contemporaneous with intrusion within the precision of measurement of the K-Ar technique. Age dating of the Laramide-Cenozoic interval in the Southwest reported by Damon and Mauger (1966) has indicated two distinct pulses, one of Laramide plutonic activity between 50 and 75 million years ago and one of dominantly extrusive activity during the mid Tertiary time approximately 30 million years ago.

Ages in Table 1 are for deposits in British Columbia and South America as well as southwestern American deposits. Five out of 26 deposits

are reported in the mid Tertiary range of 30-37 million years, 17 out of 26 are probably in the Laramide range of 59 to 72 million years, 3 are in the Nevadan range of 122 to 143 million years, and 1 deposit has a 200 million year Triassic date. Of the Southwest deposits included in Table 1, all are of Laramide age except three mid Tertiary deposits (Climax, Questa, and Bingham) and two Nevadan-age deposits (Bisbee and Ely). Two of the three mid Tertiary deposits are porphyry molybdenum deposits.

A tabulation of British Columbian deposits recently published by White, Harakal, and Carter (1968) indicates that 5 out of 15 copper and/or molybdenum deposits have potassium-argon ages in the range of 165 to 205 m.y., 8 are in the range of 45 to 55 m.y., and the reamining 2 are 100 m.y. and 140 m.y. old respectively. Although the authors do not consider the geographic distribution of these British Columbia dates in terms of belts, posting them indicates that the 165-205 m.y. dates are concentrated in a N 70 W-trending belt just east of the Coast Range batholith. This belt also contains the Endako and Boss Mountain molybdenum deposits which have ages of 142 and 100 m.y. respectively. These molybdenum deposits average about 60 m.y. younger than the copper deposits in the belt. Just west of the 165-205 m.y. belt is a cluster of Laramide-age (50-79 m.y.) deposits along the east border of the Coast Range batholith. Farther to the southwest near the west border of the Coast Range batholith recent age dating suggests the presence of several stocks and some mineralization of mid Tertiary age.

The pattern emerging in British Columbia seems to be one of parallel, overlapping, northwest trending belts of mineralization which increase in age from west to east. It is interesting to note that two of the porphyry molybdenum deposit dates are substantially younger than the surrounding cluster of porphyry copper deposits. An analogy might be drawn between

this situation and the presence of the relatively young Climax and Questa porphyry molybdenum deposits associated with the southwestern American porphyry copper province.

The single South American age in Table 1 is for Toquepala, Peru, and falls in the Laramide range (59 m.y.). However, geologic relationships together with recent absolute age dating by Chilean government geologists indicate that many of the South American porphyry copper deposits are of mid Tertiary age.

This fragmentary evidence suggests that repeated pulses of intrusive activity and porphyry copper mineralization have occurred in each of the principal porphyry copper districts, but that in a very general way the locus of mineralization may have progressively shifted from British Columbia to the Southwest to Peru and Chile in successive periods of activity. That the Southwestern porphyry copper deposits are dominantly of Laramide age is now well established.

Controlling Structures (Column 5)

Column 5 lists attitudes of regional-scale structures thought to have controlled the emplacement of the stocks and batholiths and hence ultimately the porphyry deposits themselves. Consideration was given to local structure as evidenced by published mine and district maps in preparing Column 5, but many bounding faults shown on these maps are of postore age or of multiple age such that their preore importance cannot reliably be established. Greater reliance was therefore placed upon direct statements in text than upon maps. Several authors comment that the specifics of controlling structures were obliterated by the intrusions which they guided. Posting of data from Column 5 on a coarse Rose diagram base indicates the importance of the northwest and northeast structures in localizing the deposits in southwestern North America. Of the 28 bearings

cited in Column 5 for this deposit group, 11 are northeast, 10 are northwest, 3 are north northwest, and 2 each fall in N-S and E-W orientation. The northeast group reflects both regional Precambrian schistosity and apparent important Laramide stresses. The importance of the northwesterly group to porphyry copper deposit distribution is considered by Mayo (1954), Schmitt (1966), and Guilbert and Sumner (1968).

Shape and Size (Columns 6 and 7)

The shapes of intrusions, like determinations of their size (Columns 6 and 7), are difficult to establish meaningfully, both having been affected by a number of external variables. Degree of exposure of a pluton is certainly affected by original depth of intrusion and by the nature of post-intrusion tectonic and erosional history. The Boulder batholith has been exposed for tens of miles in each direction, while a postulated southern Arizona batholith (Ettinger, 1955) may be implied by the numerous stocks and shallowly exposed cupolas of this area. Essentially cogenetic and contemporaneous extrusive activity is a shape-size factor, as are regional and local contemporaneous and later faulting and uplift. It is apparent from Table 1 that most of the host igneous bodies exhibit minor elongation, and that districts with strong structural control also tend to involve pronouncedly elongate stocks. A plot of short dimension against long produces a broad cluster with a slope of about 2 suggesting a low incidence of equidimensional intrusion and thus perhaps a low incidence of nonstructurally guided stock-batholith emplacement. Column 7 lists the size of igneous host rock outcrops for each district, the numbers having been taken from text or measured geologic maps. These dimensions are in part subject to the same uncertainties as Column 6. They indicate that the porphyry copper deposit environment was commonly developed in stocks with cross sections of well under a square mile at the elevation of ore deposition. There appear

to be two host rock size populations, one group less than a mile square and another smaller group of very large dimensions, with relatively few intrusive hosts falling in the middle-size range.

Mode of Emplacement (Column 8)

These entries adopt the terminology and confirm the conclusions of Stringham (1966) extended to include the additional porphyry copper deposits described here. Emplacement of the porphyry copper deposit host rocks is shown to be almost totally passive. Implicit in this dominance is the importance of replacement, resorption, and assimilation with respect to shouldering aside and other manifestations of forceful intrusion, and the likelihood that both lateral and vertical petrologic zoning might be more common than has been recognized. Consideration of Column 8 with Columns 41 and 42, the latter brecciation and shattering specifically within the orebodies, reveals that brecciation and/or shattering are associated with ore deposition in every porphyry deposit, even where emplacement of the host stocks is passive. This disparity suggests that the brecciation and shattering are themselves "passive," and that they can commonly be expected to have been "blind" and probably of solution origin. Forceful intrusion and active, even explosive brecciation as at Toquepala, are apparently of rare occurrence. The extent of magmatic stoping, assimilation, and metasomatism appears mechanically and kinetically inconsistent with extremely shallow emplacement, but moderately near-surface environments are again indicated.

Stock-Dike (Column 9)

The "stock-dike" column (Column 9) indicates that stocks and stocks with subordinate associated diking are far more typically associated with porphyry copper deposit genesis than are dikes, dike swarms, or breccias alone. Implicit is the association revealed in Column 6 of porphyry deposits with equidimension to oval bodies rather than with tabular

or linear ones. Twenty-three of the 26 deposits involve important stock development and a high ratio of stock characteristics to dike forms.

Sequence of Intrusion and Rock Types Mineralized (Columns 10 and 11)

The sequence of intrusion column reinforces early observations (Buddington, 1933) of the association of copper deposits with intermediate to felsic igneous rocks. Except for generally late diabase dikes, no rocks more mafic than diorite occur in the direct sequence of "intrusive" events associated with copper deposit formation. Granodiorite and quartz monzonite and their aphanitic and hypabyssal equivalents are overwhelmingly most important to the porphyry copper deposits, with more felsic variants common to the porphyry molybdenums. Most of the papers consulted in the preparation of Table 1 were carefully explicit on the sequence of intrusive events and compositions, but uncertain field relationships coupled with paucity of absolute age determinations seldom permit unequivocal identification of the beginning and ending of the magmatic episode that involved ore mineralization. No attempt is made in Column 10, therefore, to determine whether the events listed are parts of a single complex intrusive event or successive consanguineous intrusions. Much older and much younger rocks, as described in the appropriate references, are excluded. Column 11 shows that all of the igneous rocks of Column 10 are mineralized in 22 of the 26 deposits tabulated and the latest rocks are mineralized in 2 of the remaining 4.

Several relationships are apparent from Columns 10 and 11. The sequence is generally from dioritic to monzonitic rocks, commonly with the development of late latitic to rhyolitic or "quartz feldspar" intrusions. Typically, all of these rock types at a given locale are mineralized, so it is evident that mineralization either spanned or succeeded, however briefly, the emplacement of plutonic rocks where both plutonic and

hypabyssal rocks occur. The association of porphyry copper deposits with intermediate plutonic rocks is impressive but not as universal as the association with porphyritic rocks, the latter occurring in all 26 districts in Table 1. The lamprophyre or "late diabase" event is less common in the porphyry coppers than it has been thought to be (Spurr, 1925), late diabase having been reported in only 5 of the 26 districts. The general trend, clearly, is from dioritic plutonic toward more felsic hypabyssal rocks with all rock types typically mineralized. The degree to which the shift from dioritic through granodioritic to monzonitic rocks may reflect K-feldspar enrichment via ore-deposition-related potassic alteration (Peters, et al, 1966) will be considered below. Dioritic rocks commonly occur at intrusion margins, as at Ajo and Mineral Park, with progressively more K-feldspathic rocks inward, a relationship not apparent in the table. The distribution is consistent with apparent felsic-component enrichment accompanying potassic alteration near the central portions of some porphyry copper deposits.

Orebody

Outward Shape (Column 12)

The porphyry copper deposits almost all have circular or oval cross sections. At least four of the deposits have clearly defined low-grade centers which produce a ringlike orebody shape in plan. It is difficult to interpret the vertical dimension of hypogene mineralization in most deposits because relatively little data are available substantially below the surface exposure or on precise distribution of primary and secondary sulfides with depth, but the tabulated hypogene mineral bodies seem to fall into three general configurations:

1. Sixteen deposits have the general shape of a steep-walled cylinder. Included in this group are two deposits (Cananea and Toquepala) which approximately coincide in space with breccia pipes.

2. Seven deposits have the general shape of a stubby cylinder or flat, inverted cone, or shield form. All three of the porphyry molybdenum deposits fall in this group.

3. Three deposits (Inspiration, Ely, and Safford) have a gently dipping, tabular shape. This form may represent a Type 2 deposit elongated by a controlling preore structure or by postore displacement.

Boundaries (Column 13)

In all of the deposits studied, the orebody boundaries are at least in part the original gradational or "assay wall" boundaries. All of the orebodies have been intersected by a postore erosion surface. Eleven of the 26 deposits are bounded by at least one postore fault. Two of the deposits coincide closely with breccia pipes which are preore or contemporaneous with ore.

Percent in Igneous Host and Preore Rocks (Columns 14 and 15)

In several deposits, 100 percent of the mineralization is in igneous host rocks (Butte, Castle Dome, Copper Cities, Endako, and Mineral Park). All of the deposits contain some ore in igneous host rocks, but the bulk of mineralization at Bisbee, Mission, and Ray is in preore rocks. Something like 30 percent of all mineralization associated with porphyries occurs in preore rocks, a figure again suggesting cupola-type or at least high-level magmatic development of the porphyry environment.

Dimensions (Column 16)

Horizontal dimensions of the tabulated deposits range from 250 x 1200 feet for the La Colorada pipe at Cananea to 6000 x 13,000 feet for Morenci and the difficult-to-limit Butte district, the fringes of which may reach to dimensions like 20,000 x 50,000 feet (only the highly "porphyry equivalent" for Butte is cited in Column 16). The average deposit size

deduced from published descriptions and maps is perhaps surprisingly 3500 x 5000 feet.

Total Ore Tonnage and Grade (Columns 17, 18, and 19)

Of the 26 deposits tabulated 12 are estimated to contain over 500,000,000 tons of ore, 6 fall between 100,000,000 and 500,000,000 tons, and 8 contain less than 100,000,000 tons. These tonnage estimates must be considered only approximate. Tonnage figures are rarely published, and these numbers are calculated from published deposit dimensions, mill capacities, and so on, and could be considered essentially public information.

Included in these figures are a number of deposits in which ore grade depends on secondary chalcocite enrichment. Average grade of copper ore is 0.80% Cu, and average grade of hypogene mineralization, where this information is available, is 0.46% Cu. Eleven copper deposits contain at least 0.5% Cu in hypogene mineralization, and ten contain less than 0.5% Cu. Molybdenum deposits average 0.16% Mo in grade. It has been noted that there is apparent regional zoning of primary copper from higher contents to lower ones eastward in southwestern United States, with molybdenum content concomittantly increasing eastward.

Hypogene Alteration

This section of Table 1 (Columns 20 through 27) is part of and in parallel with the two sections which follow: the first on Hypogene Mineralization (Columns 28 through 35), the second on Occurrence of Sulfides (Columns 36 through 42). These three blocks are set up so that alteration, mineralization, and sulfide occurrence for a single zone in a given deposit are reported in the three columns with identical headings: for example, the innermost alteration zone at San Manuel-Kalamazoo consists of quartz, K-feldspar, biotite, and minor anhydrite (Column 25), the sulfides

occurring with it are pyrite, chalcopyrite, and molybdenite (Column 32, with amounts), and they occur as disseminations more significantly than veinlets (Column 40). It must be restated here that the table is based as completely as possible upon published descriptions, descriptions which are hardly uniform in approach, detail, and even terminology. Several deposit descriptions were based on temporal rather than spatial relationships; these deposits we entered as earliest equals innermost, and so on outward. Several deposit descriptions involved separate and poorly related descriptions of alteration, mineralization, and occurrence, and we have made every effort to match appropriate spatial and mineralogical data. Question marks in the table generally denote uncertainty of placement of the information rather than uncertainty in the data itself.

In discussing the alteration of porphyry copper deposits, we have adopted four alteration assemblages, the potassic, phyllic, argillic, and propylitic. The potassic assemblage is generally one of quartz with at least two of the three minerals K-feldspar, biotite, and sericite. Sericite, where present, is subordinate to minor. Anhydrite appears increasingly important and diagnostic as a trace mineral, along with other calcium salts. Potassic assemblages commonly yield abruptly to an assemblage consisting essentially of quartz, sericite, and pyrite, which we have called the phyllic assemblage. The usage is adopted to distinguish this characteristic sericite-dominated assemblage from the generally next outward argillic zone. The argillic zone, well established in the literature, consists of important but not quantitatively dominant phyllic minerals which are as properly designated argillic--kaolin and montmorillonite, with lesser sericite and chlorite. The fourth category is the propylitic assemblage alteration minerals, which are dominated by chlorite, epidote, and carbonates. (See Hemley and Jones, 1964; Creasey, 1966; and Meyer and Hemley, 1968

for greater mineralogical detail on these assemblages.) These are the assemblages abbreviated Pot, Phyl, Arg, and Prop in Table 1.

Review of the data in Table 1 reveals some repetitive, unifying, alteration features of the porphyry copper deposit group. The table was set up so that if a phyllic (Quartz-sericite-pyrite) zone was described it was placed in Column 24 headed "Inner Zone." Other assemblages were then entered wherever they fell according to the descriptions. As the table developed, it became apparent that what could best be described as the innermost zone was typically potassic, the inner zone phyllic, the intermediate zone argillic, and the outer zone propylitic. The assemblages were thus entered where no contrary evidence was at hand. There are, therefore, some open spaces in the table where an assemblage, for example, one consistent with "argillic," was not observed or described.

Known Extent Beyond Ore and Peripheral Zone (Columns 20 and 21)

Column 20 records the stated or mapped extent of alteration beyond the outer reaches of the orebody itself. These distances are somewhat uncertain since different observers drew the outer line on different criteria. External alteration is narrowest around the Bethlehem, B.C., deposit, a characteristic of a majority of the Canadian porphyry deposits. Other deposits show alteration in thousands of feet, averaging approximately 2,500 feet. The higher numbers probably represent some merging of hydrothermal with low-rank metamorphic effects, the two being discernible only with difficulty. Significant is the fact that detectable alteration effects do indeed extend laterally to an average distance of half a mile beyond porphyry orebodies. This may well be a low figure, since some authors drew the outer limit on the basis of "bleaching" and the presence of sericite, phenomena that may not mark the outer limit of alteration.

Peripheral Zone (Column 21)

The peripheral zone column was included principally to permit notation of skarn zones of which 5, at Bingham, Mission-Pima, morenci, Santa Rita, and SilverBell, are reported, and of alteration associated with the commonly described peripheral mineralization. The mineralization is noted for all 26 deposits, but alteration associated with it is in effect not described; Column 21 should be filled with ND symbols, since data for the mineralization is reported in Column 28. Where alteration mineralogy is given, it is of mixed affinity, dominantly propylitic, with sericite mentioned at Questa.

Outer Zone (Column 22)

Mineralogic notation is given for 20 of the 26 deposits in Table 1, with "propylitic" for Ely, Nevada. Of these 20 descriptions, 18 include chlorite, 16 include epidote, and 12 include a carbonate, 10 of which specify calcite. Quartz is cited 7 times, sericite 6 times, zoisite-clinozoisite 5, kaolin 3, montmorillonite 2, and albite, hematite, specularite and rutile(?) once each. More important than numerical frequency, clearly, is the occurrence of assemblages, and by far the most common is chlorite-epidote-calcite. Replaced minerals are seldom discussed; these replacement minerals are presumably dominantly after amphibole, biotite, and plagioclase. As indicated, it may be difficult to distinguish between a hydrothermally propylitized assemblage and a low-rank metamorphic facies. It is significant that this assemblage has affected by far the largest volume of rock. The chlorite, epidote, calcite propylitic assemblage always occurs outside the ore zone and beyond the phyllic and argillic volumes as will be developed later.

Intermediate Zone (Column 23)

This column proved to receive predominantly argillic assemblage descriptions. Silicification is clearly more important here than in the Outer Zone, and the dominant minerals are quartz, kaolin, montmorillonite, and sericite. Argillic assemblages, whether or not they actually fall in Column 23, are discernible in the descriptions of 21 of the 26 deposits, if quartz-sericite-kaolinite (4 occurrences) be included as argillic. Most of the assemblages cite quartz first. Kaolin is cited singly or before montmorillonite in 17 out of the 21 assemblages for which mineralogic data are given. Three deposits indicate montmorillonite zonally beyond kaolin, and 7 involve sericite, including the four quartz-sericite-kaolinite occurrences mentioned above. An argillic assemblage is unreported from 5 deposits.

Inner Zone (Column 24)

Into the Inner Zone column fall most of the quartz, sericite (pyrite) assemblages, the chief ore bearers of the porphyry copper deposits. The zone is reported unequivocally as a pervasive quartz, sericite assemblage at 19 porphyry districts, as quartz, major sericite, minor K-feldspar at 3 more, and as quartz, major sericite, minor kaolin at 3 more. Only at Esperanza is a quartz, K-feldspar pair reported zonally outside of an unusual quartz, sericite, K feldspar, biotite assemblage. Creasey (1966) indicates that K-feldspar can be part of his quartz, muscovite assemblage; that assemblage occurs at Bagdad, Bingham, and Chuquicamata. Creasey states (1966, p. 62) that "Quartz, sericite, pyrite without either a clay mineral or K-feldspar associated is a common assemblage that does not fit into any of the three previously described alteration types. If clay were present [as at Bagdad, Bingham, and Chuquicamata--JDL, JMG], it would belong to the potassic." Since the assemblage appears by far

most commonly as quartz, sericite, pyrite in the porphyry copper environment, the term "phyllic" is urged as a distinct type for that deposit group. Advanced argillic alteration, involving chiefly pyrophyllite, dickite, and topaz (Meyer and Hemley, 1968), is associated with phyllic assemblages at Butte and Bisbee. It is not reported elsewhere but may only have escaped detection.

The phyllic assemblage of Column 24 is the highest intensity exposed alteration assemblage in at least six districts.

Innermost Zone (Column 25)

This column is perhaps the most surprising of the hypogene alteration data block. It indicates that potassic alteration, in spite of relatively scant attention given it per se in the literature, is encountered at most of the porphyry copper-molybdenum deposits as either an early or an innermost assemblage or both. It is reported as simple quartz, K-feldspar, biotite(?) only at Endako, as quartz, K-feldspar, biotite, sericite at 7 deposits, and as quartz, K-feldspar, biotite with chlorite, albite, fluorite, anhydrite, or tourmaline at 7 more. Quartz, K-feldspar, sericite is reported at Silver Bell, and quartz only with K-feldspar occurs at Mineral Park and Questa. Quartz, phlogopite, tourmaline occurs at Cananea, but it may not be innermost there. Anhydrite at several locales is given in parenthesis in Table 1 because it has not been described in print, but pieces of anhydrite from Ajo, Bingham, Esperanza, Questa, San Manuel-Kalamazoo, and Santa Rita are on hand to swell the published occurrences at Butte, El Salvador, and Toquepala. Anhydrite is also reported from Braden, a deposit not included in Table 1. Other characteristics of the potassic zone are briefly described by Meyer and Hemley (1968) and Guilbert and Lowell (1968). Ore values commonly occur at the interface between potassic and phyllic alteration zones, as developed below. The

potassic zone is almost always most central or deepest or earliest if a time sequence is discernible.

Zoning Sequence from Center and Bottom (Columns 26 and 27)

The upward and outward zoning sequence of alteration assemblages is seldom reported as such in the articles upon which Table 1 is based, but their systematic entry by description or from map or diagram reveals a remarkable and doubtiessly significant sequence. Most significant is the fact that 6 and possibly 7 (the position of phyllic alteration at El Salvador is uncertain) of the deposits show alteration assemblages in the same outward sequence: potassic, phyllic, argillic, and propylitic. Significant also is the fact that even where certain assemblages are not reported, the remaining assemblages fall into the same order. Two deposits, possibly 3, show only potassic and phyllic, 4 show the sequence lacking only argillic, and 6 show the sequence starting with phyllic and including argillic and propylitic. Either the geology or the descriptions prevent assignment of sequence for a few deposits. Vertical sequence or zonation is generally much less well known and described, so assignments can be made in Column 27 only for Butte, Climax, El Salvador, and San Manuel-Kalamazoo. Except for uncertainty with the El Salvador sequence, the order is consistent with lateral zoning and supports the conclusion that outward and upward zoning of the 26 major porphyry copper and molybdenum deposits is reliably shown to be of potassic, phyllic, argillic, and propylitic assemblages. Mineralizational conclusions will be developed in the next sections.

Hypogene Mineralization

As has been shown by many authors and articles, hypogene ore mineral assemblages are closely interrelated in time and space with porphyry copper deposit alteration mineral assemblages. The designation of

pyrite and magnetite as ore minerals rather than as alteration minerals, for example, is largely an arbitrary decision.

In Table 1, sulfide-oxide mineral assemblages have been described in Columns 28-35 with reference to the same zones defined by alteration minerals in Columns 20-27. The excellent consistency apparent through each of the mineralization zones and the consistent variation from one particular assemblage to another outward from the center suggests that this is a valid framework.

Peripheral Alteration Zone (Column 28)

This column contains base and precious metal occurrences which form a discontinuous ring typically near the outer edge of the propylitic zone. The occurrences tend to be only small to medium sized deposits, although large lead-zinc deposits with or without precious metals occur in this zone at Santa Rita, Bingham, and Butte. At least minor occurrences of peripheral mineralization are found in all 26 of the deposits studied. Peripheral mineralization was a geometrically diagnostic feature consisting of arcuate clusters of mines or mineral prospects in 22 of the deposits. Minerals found in this zone are commonly sphalerite, galena, silver, chalcopyrite, gold, and pyrite. Less commonly, specularite, enargite, famatinite, tetrahedrite, barite, and manganese and vanadium minerals are found.

Outer Alteration Zone (Column 29)

This zone generally corresponds to the propylitic alteration zone, and mineralization is generally restricted to pyrite, though sparse chalcopyrite is usually present together with variable amounts of bornite, molybdenite, magnetite, specularite, rhodochrosite, sphalerite, galena, and rhodonite.

Intermediate Alteration Zone (Column 30)

This corresponds roughly to the argillic alteration zone, and the bulk of mineralization is usually pyrite with a high pyrite to chalcopyrite ratio which averages 23:1 in the deposits for which quantitative figures are available. Variable amounts of bornite, molybdenite, tennantite, sphalerite, galena, enargite, chalcocite, and huebnerite have been found in this zone. Hypogene ore-grade mineralization may overlap into this zone, but this zone is generally outside of the orebody.

Inner Alteration Zone (Column 31)

This zone commonly corresponds to the phyllic alteration zone and typically contains abundant pyrite and high total sulfides together with pervasive sericitization. Pyrite content averages about 5 percent for the 26 deposits, or about 8 percent, excluding the porphyry molybdenum group. Pyrite to chalcopyrite ratio averages 12.5:1. This zone commonly constitutes the ore zone in porphyry copper deposits, especially those in which chalcocite enrichment has occurred. In addition to pyrite, chalcopyrite, molybdenite, and variable but generally small amounts of bornite, chalcocite, sphalerite, enargite, and magnetite occur.

Innermost Alteration Zone (Column 32)

This zone is generally equivalent to the potassic alteration zone and is usually the central zone in the concentric alteration-mineralization pattern. Total sulfide content is low to moderate with an average pyrite content of about 1 percent and a pyrite to chalcopyrite ratio of 3:1 in the deposits tabulated. This zone may reach hypogene ore grade, and it probably accounts for the majority of ore grade materials in solely hypogene ore deposits. It also forms the "low-grade center" in a number of deposits. Five of the 26 deposits show some development of a low-grade center. The mineral assemblage is chalcopyrite, pyrite, and molybdenite,

uncommonly accompanied by bornite. Furthermore, where copper and molybdenum occur in the same deposit, molybdenite is decidedly more abundant in the more central or deeper portions of the deposit.

Overall Abundance Major Ore Minerals (Column 33)

In the porphyry copper systems which were tabulated, pyrite is by far the most common mineral present. Following in order of abundance are chalcopyrite, bornite, enargite, and molybdenite. Molybdenite was present in all 26 of the deposits, a fact not previously recognized.

Zoning Sequence from Center (Column 34) and from Bottom (Column 35)

The typical lateral sequence appears to be pyrite, molybdenite, then pyrite, chalcopyrite, molybdenite, bornite grading outward to pyrite, chalcopyrite and to sphalerite, galena, silver, gold. Apparent reversals were noted in only three camps.

Vertical zoning sequence information is extremely limited because most deposits for which information is available have been explored by mine openings or drill holes only to shallow depths as compared with their original vertical dimension. Scant information available from 12 deposits suggests that typically a pyrite, chalcopyrite, molybdenite assemblage grades upward into pyrite. An apparent reversal of this gradation has been reported in two deposits. It must be concluded that present evidence on vertical zoning is still inconclusive.

Occurrence of Sulfides

Occurrence of hypogene sulfides in porphyry coppers is typically in the form of veinlets or disseminated grains. This habit is probably related to the fact that crackle brecciation is present throughout most of the volume of mineralization and alteration. As a broad generalization, the porphyries give the impression of being large masses of homogeneous

material penetrated by a reticulate network of fractures and mineralized by a massive infusion of fluids which soaked the mass rather than concentrating mineralization in tabular masses or replacements.

Occurrence of Sulfides in Peripheral, Outer, Intermediate, Inner and Innermost Zones (Columns 36, 37, 38, 39, and 40)

A progressive general gradation in sulfide occurrence has been noted in almost every deposit tabulted in Table 1. This sequence progresses from veins in the peripheral zone to veinlets in the outer zone, to veinlets and minor disseminated values in the intermediate zone, to veinlets approximately equal to disseminated in the inner zone, to disseminated greater than veinlets in the innermost zone. The tendency for disseminated mineralization towards the core may result from metasomatism or recrystallization of the rock and healing of earlier veinlets. The absence of prominent veins in most of the alteration zones may indicate that a crackle brecciation zone behaved as an incompetent mass which would not support through-going fissures and in which, therefore, veins could not form.

Breccia Pipes and Crackle Zones (Columns 41 and 42)

Of 26 deposits tabulated, breccia pipes are present in 19 and are mineralized in 18. Two of the deposits, Toquepala and Cananea, are mineralized breccia pipes in which ore limits are nearly coextensive with the limits of the pipes. The mineralized breccia pipes (Toquepala in particular) show evidence that the alteration zones around the deposits have been telescoped into a relatively thin alteration halo, and alteration assemblages within the orebody overlap.

A well-developed crackle zone is present in 25 of the deposits but is largely absent in the scanty mineralization of the Mission-Pima orebody. Crackle zones are usually circular in outline and are always

larger than the orebodies. They typically fade out laterally within the zone of propylitic alteration. Crackle texture is often less distinct near the center of the porphyry copper system, particularly if a potassic alteration zone is present.

Supergene Sulfides

Supergene Sulfides (Column 44)

Of the 26 deposits studied, 22 contain supergene sulfides, and secondary enrichment was required to reach marginal ore grade in 10 districts. Chalcocite is present in each of the deposits where secondary sulfides occur, and it constitutes the chief copper enrichment mineral. Covellite is reported in 12 deposits, and digenite is reported at Butte, Montana.

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ECONOMIC CLASSIFICATION OF ORE DEPOSITS

See Note (1)

CLASS	I SEDIMENTARY ENVIRONMENT	II VOLCANIC ENVIRONMENT	III PLUTONIC ENVIRONMENT	IV METAMORPHIC ASSOCIATES
TYPE	(A) Conformable Massive Sulphide Deposits	(A) Conformable Massive Sulphide Deposits	(A) Porphyry Complex Intrusion	
	(B) Conformable, Disseminated Sulphide Deposits	(B) Disseminated, Conformable Deposits	(B) Intrusive Igneous Breccia	(A) Contact Metasomatic
	(C) Disseminated, Bedded Sulphide Deposits	(C) Discordant Deposits	(C) Pipe-Like Deposits	
	(D) Mississippi Valley Deposits	(D) Pipe-Like Deposits	(D) Basic & Ult. Basic Associates	
	(E) Discordant Deposits		(E) Alkali Carbonatite Intrusives	
	(F) Pipe-Like Deposits		(F) Pegmatites	
			(G) Discordant Deposits	

Note (1) - Subtract metamorphic grade of host and enclosing rocks before making class assignments I to III.

DETAILS OF CLASSIFICATION

BASIS FOR CLASSIFICATION:

A classification is based upon many characters, not requiring any single character or property to be universal for a class. In such cases a class is established because it contains a substantial portion of the characters employed in the classification. Assignment to the class is not on the basis of a single property, but on the aggregate of properties, and any pair of members of the class will not necessarily share every character.

Fundamental to any attempt at clustering objects into homogeneous groups is the concept of Comparitive Similarity (Affinity), that is, "A is more similar to B than it is to C".

The following classification is based upon relationships of overall similarity among the objects being classified as opposed to relationships based upon common lines of descent (genetic classifications). Although close genetic relationships imply close comparitive similarity, it is not always the case.

CLASS 1 - A

CONFORMABLE MASSIVE SULPHIDE BODIES SEDIMENTARY ENVIRONMENT

DEFINITION:

Massive or primarily massive sulphide bodies occurring in a dominantly sedimentary environment. Includes the type sulphide body occurring in metamorphosed terrain where the enclosing rocks can be identified or are inferred to have originally been sediments. The type deposits are lenticular or tabular, conformable with the enclosing rocks, and frequently display sulphide banding which parallels features within the enclosing stratigraphy. Deposits may show stratigraphic restriction on a local or regional scale. Preferred host rocks are silstones, micaceous quartzites, argillites, pyritic black shales, impure limestones and dolomites.

Characteristic sulphide minerals are pyrite, pyrrhotite, sphalerite, galena, and less frequently chalcopyrite. Significant silver contents and low or trace gold values appear to be another diagnostic feature.

INCLUSIVE KEY DESCRIPTIVE WORDS:

Massive Sulphide, Conformable Bedded, Tabular, Lensoidal, Sedimentary Environment, Banded, Zinc-Lead-Copper, Copper, Stratigraphic Control, High Silver.

CLASS 1 - B

CONFORMABLE DISSEMINATED SULPHIDE DEPOSITS IN SEDIMENTARY ENVIRONMENT

DEFINITION:

Sulphide deposits of dominantly disseminated character occurring within a particular sedimentary bed: Mineralization is not primarily elongated parallel to indegeneous planar features within the host unit, and may have random orientations. Massive type-mineralization, if associated, tends to occur as veins, or along ruptures transverse or oblique to the host formation, or in breccia zones. Type deposits tend to favor impure limestones or dolomitized equivalents. Ore controls are primarily stratigraphic-structural rather than lithologic. Pyrite and pyrrhotite are common sulphide components, but heavy iron sulphide concentrations are absent. Quartz, calcite, and barite are the common gangue minerals. Extensive hydrothermal alteration is absent. Common alteration types are dolomitization and occur in tectonically disturbed terrain and may be proximate to either intrusive or extrusive igneous activity, although a causative relationship between igneous activity and mineralization is obscure. Deposits may be repetitive within a given area, but the tendency to cluster is less pronounced than for Mississippi Valley type deposits. Class 1-B includes sulphide deposits intermediate between Class 1-A and Class 1-C. Type deposits are typically moderate accumulations of Pb and zinc, ranging from 4-8% combined metals, with silver contents of 0.2 to 2.0 ounces per ton. Copper-bearing deposits are also known.

INCLUSIVE KEY DESCRIPTIVE WORDS:

Conformable, Disseminated, Tabular, Lensoid, Stratigraphic Control, Sedimentary Environment, (Zinc-Lead-Silver), (Copper).

CLASS 1 - C

DISSEMINATED, BEDDED DEPOSITS IN SEDIMENTARY ENVIRONMENT

DEFINITION:

Primarily mono or bi-metallic disseminated deposits occurring within the intergranular spaces of a specific sedimentary unit. Type deposits have a large ratio of thickness to area and are usually found within present or former intercratonic basins of generally passive tectonic setting. The primary ore control is sedimentary-lithologic rather than stratigraphic-structural. Type deposits are usually large low grade concentrations of sulphides, but lesser areas of richer concentrations may occur originally or through up-grading by regional metamorphic processes. Deposits show only remote relationship or proximity to igneous activity. Common contained metals are Cu, Pb, Cu-Zn-Pb, U_3O_8, and Au.

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KEY DESCRIPTIVE WORDS: Disseminated, Bedded, Stratigraphic Restriction, Lithologic Control.

CLASS 1 - D

MISSISSIPPI VALLEY - TYPE DEPOSITS

EXCLUDES:

Lead-Zinc deposits in carbonate strata displaying either high silver, gold, or cadmium contents, extensive hydrothermal or metasomatic alteration effects, unusually heavy iron sulphide to Pb-Zn sulphide concentrations, or deposits closely related spatially to intrusive or extrusive rocks which were once in active contact with the host strata.

DEFINITION:

Single or bi-metallic deposits of lead and zinc occurring primarily in dolomite or dolomitized limestone strata. Deposits are characteristically of low grade 3-6% Pb-Zn, although massive varieties grading upwards of 40% combined metals over limited areas, and averaging 10-15% over larger areas are known. Stratigraphic restriction of deposits is a major attribute, along with a tendency for deposits to "cluster", forming zinc "districts" or lead "belts". Deposits are often stratiform, occurring as bedded replacements within host strata; may also occur in breccia zones of tectonic or sedimentary origin, as open space fillings in vugs and reefoid areas as fissure and fracture fillings, and as cave fillings. Primary sulphide minerals are sphalerite and galena; pyrite and marcasite are common accessory sulphides, although iron sulphides may be entirely absent. Chalcopyrite may be a rare constituent of the ore. Gangue minerals are commonly calcite, and dolomite; barite, and flourite may also be present. The more massive sulphide fabrics frequently show colloform banding of alternating low and high iron sphalerite. Low or absent silver, gold and cadmium values are another diagnostic feature. Most deposits occur within tectonically passive regions, devoid of intrusive or extrusive ignious activity however, many areas show complex fault patterns. The bulk of deposits occur in Palaeozoic age strata, although similar deposits exist in late precambrian dolomites.

INCLUSIVE KEY DESCRIPTIVE WORDS:

Lead, Zinc, or Lead-Zinc, Carbonate Strata, Passive Tectonic Setting, Stratigraphic Restriction, Dolomitization, Low Silver and/or Cadmium Content, Stratiform, Open Space Filling.

CLASS 1 - E

DISCORDANT DEPOSITS IN SEDIMENTARY ENVIRONMENT

DEFINITION:

Any discordant mineral filled feature (exclusive of pipe like deposits) whose initial formation produced void(s) in the country rock which acted as

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a receptacle or locus of deposition for introduced mineralizing solutions. A great size range occurs among these features from occurrences to mineable ore bodies, of which the latter constitute a very small proportion of the total population. Type deposits are thin-tabular, usually steeply dipping in the case of veins and fissures, or irregular in outline when controlled by ruptured folds and tectonic breccias. Alteration if present, has a limited lateral extent being generally closely confined to the mineralized structure. Deposits are usually multi-metallic and characterized by a great variety of mineral associations. The size of individual deposits depends on the magnitude and regularity of the controlling structure.

Type occurrences may be significant as indicators of potential large tonnage bedded or conformable deposits, because such features sometimes form as tangential or tributary features to the stratiform type of deposit, or exist in stratigraphy potentially favourable for the larger type of deposit. When making this evaluation, the mineral content of the discordant feature should be assessed against both the immediate and total geologic environment. A classification of this kind would be Discordant Sedimentary Environment/Potential - Mississippi Valley.

KEY DESCRIPTIVE WORDS:

Discordant, Structural Control, Introduced Mineralization, Veins, Shears, Faults, Fissures, Ruptured Folds, Tectonic Breccia Zones.

CLASS 11 - A

CONFORMABLE MASSIVE SULPHIDE DEPOSITS IN VOLCANIC ENVIRONMENT

DEFINITION:

Conformable massive sulphide bodies which occur primarily, though not exclusively, within acidic volcanic flow rocks frequently of pyroclastic nature; also in tuffaceous interbeds or at the interface of volcanic piles and overlying sediments; may also occur in metamorphosed equivalents of the above host rocks. Sulphide bodies are usually conformable with the enclosing wall rock and frequently display macro and micro banding of sulphide layers. Deposits may be stratigraphically restricted on a local and/or regional scale, and may display a zonal arrangement to centres of volcanic activity. The ore-bodies are chiefly enrichments of copper and zinc, although certain types are trimetallic and contain copper-zinc and lead. The type deposit is further distinguished by a usually significant silver and/or gold content. Primary sulphide minerals are chalcopyrite, sphalerite, galena, pyrite, and pyrrhotite; common accessory minerals are magnetite, arsenopyrite, bornite, tennantite, and tetrahedrite.

INCLUSIVE KEY DESCRIPTIVE WORDS: Massive Sulphides, Conformable, Volcanic Environment, Copper, Copper-Zinc, or Copper-Zinc-Lead, (Au) (Ag), Banded, Stratigraphic Control, Acidic-Pyroclastic-Tuffaceous Host Rocks, Volcanic Centres.

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CLASS II - B

DISSEMINATED, CONFORMABLE DEPOSITS IN VOLCANIC ENVIRONMENT

DEFINITION:

Type deposits are typically low to moderate grade disseminated concentrations of copper in volcanic flow rocks of intermediate to basic composition. Sulphide accumulations may tend to favour the porous, vesiculated, brecciated and fragmental flow tops, or occur in intercalated arenaceous and conglomeratic sediments of contemporary origin. As such, this mode of mineralization qualifies as disseminated sedimentary environment, except for the close proximity of extrusive volcanic rocks containing deposits of the same minerals. Common copper minerals are native copper, chalcocite, chalcopyrite, and bornite. Known producing districts occur in Precambrian age areas of simple to moderate tectonic complexity representing the extensive accumulation of extrusive volcanic flows and contemporary sediments. The type deposit should include all disseminated, conformable occurrences in flow rocks having a high thickness/area ratio.

INCLUSIVE KEY DESCRIPTIVE WORDS: Disseminated, Conformable, Intermediate to Basic Composition, Flow Rocks, Flow Tops, Flow Breccia, Amygdaloidal, Vesicular, Large Ratio Thickness/Area.

CLASS II - C

DISCORDANT DEPOSITS IN VOLCANIC ENVIRONMENT

DEFINITION:

Any discordant mineral filled feature (exclusive of pipe-like deposits) whose initial formation produced void(s) in the country rock which acted as a receptacle or locus of deposition for introduced mineralizing solutions. A great size range occurs among these features from occurrences to mineable ore bodies, which constitute a very small porportion of the total population. Type deposits are thin-tabular, usually steeply dipping in the case of veins and tectonic breccias. Alteration if present, has a limited lateral extent being generally closely confined to the mineralized structure. Deposits are usually multi-metallic and characterized by a great variety of mineral associations. The size of individual deposits depends on the magnitude and regularity of the controlling structure.

Type occurrences may be significant as indicators or potential large tonnage conformable massive sulphide or disseminated deposits, because such features sometimes form as tangential or tributary features to the conformable type of deposit, or exist in stratigraphy potentially favourable for the larger type deposit. When making this evaluation, the mineral content of the discordant feature should be assessed against both the immediate and total geologic environment. A classification of this kind would be - Discordant Volcanic Environment/Potential - Disseminated Bedded Volcanic Environment.

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KEY DESCRIPTIVE WORDS: Discordant, Structural Control, Introduced Mineralization, Veins, Shears, Faults, Fissures, Ruptured Folds, Tectonic Breccia Zones.

CLASS III - A

PORPHYRY-TYPE COPPER AND MOLYBDENUM DEPOSITS

EXCLUDE: Contact metasomatic or metamorphic deposits where widespread dissemination of sulphides is lacking or where skarn and/or tactite alteration are the dominant influences on ore deposition.

DEFINITION:

A broad term referring to large tonnage disseminated deposits of copper and/or molybdenite occurring within igneous plutonic rocks ranging in composition from granodiorite, syenite, monzonite to quartz-diorite including the porphyritic equivalents. The average metal content of the type deposit is usually less than 2% Cu, and is more commonly in the range of 0.5 to 1.5% for Copper. Ore grade values for molybdenum from deposits currently being mined range from 0.1% to 0.5% molybdenite. Low gold and silver values are frequently present. Deposits are found primarily in areas of multiple intrusion with a complex tectonic history. Sulphide minerals occur as discrete disseminations, spangles, blebs, as swarms of veinlets, or as coatings on fracture faces. The deposits are structurally rather than stratigraphically controlled, the degree of fracturing being the most important factor.

Common sulphide minerals are chalcopyrite, bornite and pyrite. Accessory minerals are variable and may consist of specularite, magnetite, molybdenite, sphalerite and chalcocite. Extensive alteration of intrusive host rocks is a diagnostic feature of all deposits. Common alteration types are:

Quartz-orthoclase (pegmatization)
Quartz-sericite - pyrite
Sericite - argillic
Biotite
Epidote
Chlorite

Breccia zones within altered instrusives are frequently highly favourable for sulphide accumulation. In many deposits ore values are found in contiguous sedimentary or volcanic rocks. In some cases country rocks show the effects of pyrometasomatism and/or contact metamorphis however, in true "porphyry-type" deposits such effects do not constitute the dominant mode of ore emplacement.

Ore zones are generally irregular, circular areas of concentration, but shapes such as lenses, blankets, or even linear and steeply dipping zones are also known, individually or as components of the overall deposit.

Porphyry-type deposits are further distinguished by anomalous amounts of rhenium contained in the mineral molybdenite, compared to the rhenium content of molybdenites from other classes of deposits.

INCLUSIVE KEY DESCRIPTIVE WORDS: Disseminated, Porphyry, Large Tonnage, Cu, Mo, Cu-Mo, Multiple Intrusion, Complex Tectonics, Structural Control, Sulphide Emplacement in Contiguous Rocks.

CLASS III - G

DISCORDANT DEPOSITS IN PLUTONIC ENVIRONMENT

DEFINITION:

Any discordant mineral filled feature (exclusive of pipe-like deposits) whose initial formation produced void(s) in the country rock which acted as a receptacle or locus of deposition for introduced mineralizing solutions. A great size range occurs among these features from occurrences to mineable ore bodies, which constitute a very small proportion of the total population. Type deposits are thin-tabular, usually steeply dipping in the case of veins and fissures, or irregular in outline when controlled by ruptured folds and tectonic breccias. Alteration if present, has a limited lateral extent being generally closely confined to the mineralized structure. Deposits are usually multi-metallic and characterized by a great variety of mineral associations. The size of individual deposits depends on the magnitude and regularity of the controlling structure.

Type occurrences may be significant as indicators of potential large tonnage porphyry, igneous breccia, contact metamorphic, or contact metasomatic type deposits, because such features sometimes from as tangential or tributary features to these larger deposits, or exist in lithologies potentially favourable for large volume ore emplacement. When making this evaluation the mineral content of the discordant feature should be assessed against both the immediate and the total geologic environment. A classification of this kind would be - Discordant Plutonic Environment/Potential Porphyry Copper.

CLASS IV

CONTACT METAMORPHIC, METASOMATIC, AND PYROMETASOMATIC DEPOSITS

DEFINITION:

Either massive or disseminated deposits of multi-metallic composition

which occur at the zone of chemical interaction between intrusive or extrusive igneous rocks and the intruded or extrusively covered country rocks. The type deposits display a clear causative relationship between igneous activity and ore deposition. Rock bounding the sulphide deposit shows the effects of either high temperature or pressure and/or chemical reaction, by the physical presence of hydrothermal alteration of pre-existing rock minerals, formation of skarn, tactite, or hornfels. The three deposit varieties noted above may occur individually or in some combination of the various metamorphic processes. Chemically reactive rocks such as limestones and dolomites are particularly receptive to the type deposit. Many features of these deposits are partially if not wholly associated with deposits of the porphyry and intrusive breccia class. The decision to class a deposit of the porphyry or metamorphic type rests largely on the features of size, gross environment, and the disseminated fabric of mineralization. Porphyry or intrusive igneous breccia deposits with significant attributes of the metamorphic class should be cross-classified with the appropriate metamorphic type, and vice versa.

INCLUSIVE KEY DESCRIPTIVE WORDS: Contact, Metamorphic, Metasomatic, Pyrometasomatic, Intrusive/Extrusive Igneous Activity, Reaction with Country Rock, Igneous Injection, Replacement, Hydrothermal Alteration, Pegmatization, Skarn Tactite, Hornfels, Tectonic Complexity.

CLASSES I-E, II-D, III-C

PIPE-LIKE DEPOSITS

DEFINITION:

A pre-mineral breccia structure which has controlled the circulation and deposition of subsequently introduced mineralization. It is composed of relatively rotated angular or rounded rock fragments set in a mineralized matrix. A pipe may be circular, oval, or polygonal in cross-section, with a steep to vertical axis proportionately much greater than its horizontal dimensions. The pipe is a steeply plunging, chimney-like mass of brecciated rock cemented with later minerals.

While pipes are generally discordant features, they are classed separately as a unique and discrete type of discordant deposit. Pipes may be further classified by appending the environment withing which they are found.

INCLUSIVE KEY DESCRIPTIVE WORDS: Pipe, Breccia, High Ratio Cross Section to Length, Steep Dipping, Vertical, Multi-Environmental.