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James Doyle Sell Mining Collection

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ASARCO

cc: J. D. Hill

Exploration Department
R. L. Brown
Vice President

May 20, 1987

Mr. David N. Skillings, Jr.
Skillings Mining Review
First Bank Place, Suite 728
Duluth, Minnesota 55802

Dear Sir:

I am informing you herewith of the death of Mr. J. Harold Courtright, retired chief geologist of ASARCO Incorporated. His obituary is attached.

Yours very truly,

R. L. Brown

R. L. Brown

RLB:mr
Att.

ASARCO Incorporated
MAY 26 1987
SW Exploration

ASARCO Incorporated 180 Maiden Lane New York, N.Y. 10038 (212) 510-2000
Telex: ITT 420585 RCA 232378 WUI 62522 Cables: MINEDEPART Telegrams: WU1-25991

OBITUARY

J. Harold Courtright

J. Harold Courtright, 78, died peacefully in his sleep on December 7, 1986, at home in Tucson, Arizona. Harold is survived by his wife Vi and their sons, James and Timothy.

Born in Yakima, Washington, Harold studied at Sacramento (CA) City College and MacKay School of Mines, Reno, Nevada.

In 1941, he joined Consolidated Copper Mines Corporation as a geologist in the Ely, Nevada district.

Harold joined ASARCO Incorporated in 1945, and remained through to his retirement at age 70. At that time Harold was chief exploration geologist, and remained as consulting geologist in the Asarco Tucson Office.

Courtright participated in the discovery of economic mineral deposits in many areas, including Leadville, Colorado; Silver Bell and Mission, Arizona; Toquepala, Cuajone and Michiquillay, Peru and Bethleham, British Columbia. His travels and work with Asarco took him to most of the continents.

Harold was a member of AIME, Arizona Geological Society (Charter Member and President), Society of Economic Geologists, Geological Society of America, and a charter member of the Mining Club of the Southwest.

Contributions to Harold's memory may be made to the J. Harold Courtright Memorial Fund, c/o Arizona Geological Society, P.O. Box 40952, University Station, Tucson, Arizona 85717. The fund is established to suppot research and field work as exemplified by Harold's life and work.

JDS

FROM: J. D. SELL 5/11/87

To: Byron Hardie

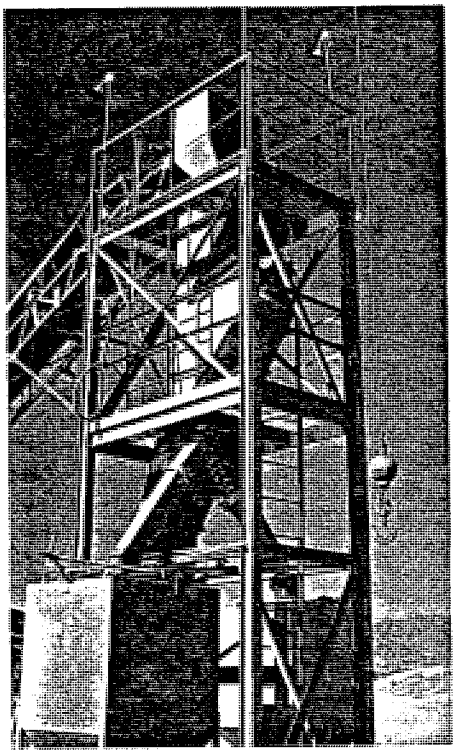
Attached are the obituary notices on J. Harold Courtright.

Jim

May 30, 1987 Vol. 76 No. 22

Skillings' Mining Review

PUBLISHED EVERY WEEK ESTABLISHED 1912



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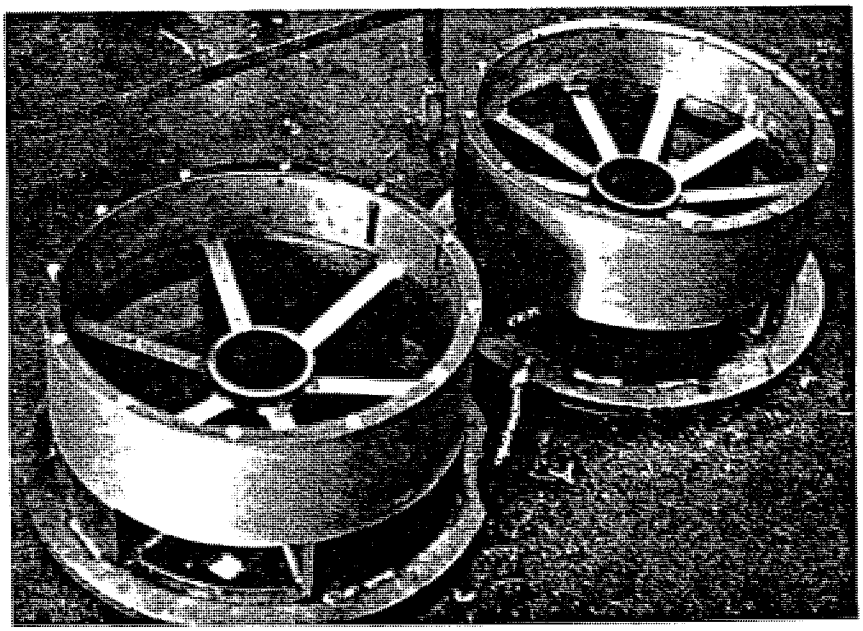
Exploration



Recent Developments in Mechanical Sampling Design—Page 4

MINING ENGINEERING

P.O. Box 625002
Littleton, CO 80162-5002
303-973-9550
FAX 303-973-3845
Telex 881988

R. L. B.
JUN 8 1987

June 5, 1987

Mr. R. L. Brown
Asarco, Inc.
180 Maiden Lane
New York, NY 10038

Dear Mr. Brown:

Thank you for sending us the appreciation of J. Harold Courtright. We plan to use it in a forthcoming issue of MINING ENGINEERING and will send you a tearsheet after it has been published.

I don't anticipate any problem in giving credit to the Exploration Department and Kenyon Richard for writing the piece.

Sincerely,

Beth Drobniewski

Beth Drobniewski
Assistant Editor

/bd

ASARCO Incorporated
JUN 1 1 1987
SW Exploration

Economic Geology
Vol. 82, 1987, pp. 1659–1660

Sept.-Oct. 1987 issue

SOCIETY OF ECONOMIC GEOLOGISTS

Walden P. Pratt, Editor for SEG Activities
U.S. Geological Survey—Mail Stop 905
Box 25046, Federal Center
Denver, Colorado 80225
Telephone (303) 236-5598

Notes and News

Notes and news of personal interest about SEG members, as well as announcements of upcoming meetings, are not only invited but eagerly solicited for the SEG pages. However, please bear in mind that there is a built-in **minimum** lag of about two months from date of submittal to date of publication.—WPP

Robert J. Wright, SEG 1951, has retired as Senior Technical Advisor, Division of Waste Management, U. S. Nuclear Regulatory Commission, Washington, D. C., and has moved to Princeton, New Jersey. He is active as a consultant in management of high-level radioactive waste.

Jack E. Harrison, SEG 1958, retired in Denver in December 1986 after a 35-year career with the U. S. Geological Survey. Harrison initiated the U. S. G. S. program of geologic mapping of 1° × 2° quadrangles, and in recent years, concentrated on the stratigraphy and geochemistry of the Belt basin, resource appraisals of the strata-bound copper-silver sulfide deposits, and regional tectonics of the Belt basin, an effort which he is continuing in semiretirement. He received the Department of Interior Distinguished Service Award in 1979.

As reported in these pages in the August issue, **William H. Gross,** SEG 1962, died suddenly in Toronto on August 6, 1987. Gross combined an active consulting career with teaching at the University of Toronto from 1950 to 1968, and then turned his full attention to mineral exploration. Among other ventures, his work resulted in the discovery of a major silver deposit in the Guanajuato area of Mexico, and this in turn led to the creation of the Lacana Mining Corporation, from which he retired as President in 1986.

The Society regrets to report the death of **J. Harold Courtright,** SEG 1952, on December 7, 1986. He had retired in 1977 as Chief Geologist of Asarco, Inc., but served actively as a consultant to Asarco until his death. As reported by his colleagues, Harold Courtright will be chiefly remembered in connection with his work with porphyry copper systems. His first formal professional appointment, which followed perhaps 15 years of on-and-off work as a miner, was with the Consolidated Copper Corporation at Kimberly, Nevada, where he first teamed up with Kenyon Richard. The two men moved over to Asarco in 1945, and their work with Asarco went far toward putting that company into the copper mining business in a substantial way. Harold's approach to geology and to exploration revolved simply around careful mapping. In the case of the porphyries, this mapping emphasized evaluation of alteration suites and leached outcrops; his knowledge of gossans was remarkable. Harold and Kenyon did most of the geologic work associated with the discovery and development of Silver

J. Harold Courtright

Bell, Mission, Toquepala, Bethlehem, Cuajone, and other deposits. Later, enlisting the services of a group of younger men willing and able to map and to reason up to his standards, Courtright directed the search for porphyry copper in most of the countries where these ores may be found. A list of discoveries resulting from this work includes Michiquilay, Sacaton, Casa Grande-Santa Cruz, La Caridad, and other deposits.

RECEIVED JDS

SPONSOR IBM

CIRCLE 5 ON READER SERVICE CARD

J. HAROLD COURTRIGHT 1908-1986

FRIENDS:

YOU WILL AGREE -- TO HAVE KNOWN HAROLD WAS AN EXPERIENCE IN A VAST NUMBER OF ASPECTS. HAROLD THE GENTLEMAN -- THE OBSERVER -- THE HELPER -- THE TUTOR -- AND THE FRIEND: TO NAME ONLY A FEW OF HIS MULTIPLE CHARACTERISTICS.

I FIRST MET HAROLD, AND A NUMBER OF OTHER GEOLOGISTS GATHERED HERE TODAY, AT THE ARIZONA GEOLOGICAL SOCIETY MEETING BEING HELD AT BUFFINS CAFETERIA AT BROADWAY AND TUCSON BLVD. WHERE THE SECONDARY ATTRACTION WAS THE CAFETERIA MOTTO OF "ALL YOU CAN EAT." IT SO HAPPENED THAT THE CAFETERIA SOON WENT OUT OF BUSINESS AND I SUSPECT IT WAS BECAUSE OF THE LIKES OF US UNDERGROUND MINE GEOLOGISTS FROM SUPERIOR WHO REALLY PILED UP THEIR PLATES, RATHER THAN THE MORE EXPERIENCED AND REASONABLE GROUP OF WHICH HAROLD WAS A PART.

A TRAIT THAT SINGLED OUT HAROLD, WHETHER AT THE AGS MEETING, OR ON A FIELD TRIP, OR WHEREVER, WAS HIS QUIET WAY OF ASKING THE PERTINENT QUESTION IN JUST THE RIGHT MANNER TO SECURE A LONG DISCOURSE ON THE SUBJECT BY THE PERSON INVOLVED. ANSWERS THAT MINE MANAGERS WOULD PROBABLY SHUTTER AT SHOULD THEY HAVE BEEN WITHIN HEARING RANGE.

IN THOSE EARLY YEARS DON HAMMER AND I ROUNDED UP THE CENTRAL ARIZONA GEOLOGY DISCUSSION GROUP BY COLLECTING THOSE INTERESTED FROM THE SUPERIOR-MIAMI-GLOBE-CHRISTMAS-RAY AREAS. THE SPEAKERS WERE MOSTLY FROM THESE LOCAL OPERATIONS, BUT WE WERE EAGER TO EXPAND OUR KNOWLEDGE. OF COURSE, THE AGS MEETINGS HELPED THAT ASPECT, BUT WITH A TWO HUNDRED MILE ROUND TRIP FACING US IT WAS NOT ALWAYS A MONTHLY EVENT FOR US OUT-OF-TOWNERS.

THUS IT WAS THAT WE CONNED HAROLD AND KENYON, WHO HAD JUST RETURNED FROM THEIR MAPPING OF THE BRECCIA PIPES AT TOQUEPALA, PERU, TO HONOR THE GROUP WITH A DISCUSSION AT SUPERIOR. TO HELP ENTICE THEM, A TOUR OF A PART OF THE MAGMA MINE WAS INCLUDED. THEN, AS NOW, FEW GEOLOGISTS CAN RESIST THE OPPORTUNITY OF VISITING AN OPERATION, EVEN IF THEY ARE ON TAP TO TALK, SO THE TWO ACCEPTED. SOME SCRIBBLED NOTES SUGGEST SOME 37 PEOPLE SHOWED UP TO HEAR THEIR DISCUSSION AND TO SEE THE VARIOUS SLABS OF BRECCIA THEY BROUGHT ALONG TO ILLUSTRATE THE FEATURES.

NATURALLY, I WAS EAGER TO EXPOUND ON THE EAST COUNTY LIMESTONE REPLACEMENT DEPOSITS AT SUPERIOR, SO I TOOK HAROLD AND KENYON THROUGH MANY DRIFTS, SUBDRIFTS, INCLINED RAISES, AND STOPES TO EXAMINE MANY FACES OF PLUS 5% COPPER ORE FOR THE TEXTURES AND MINERAL RELATIONS AS WELL AS THE MINERAL-LIMESTONE CONTACTS. AS MANY OF YOU KNOW -- MAGMA USED LOTS OF TIMBER TO SUPPORT THE GROUND, AND UNDERGROUND WAS A LITERAL FOREST OF TIMBER ON FIVE-FOOT CENTERS. AS I RECALL, WE DIDN'T CATCH THE SHAFT CAGE UP TO THE SURFACE BEFORE LUNCH -- PROBABLY BECAUSE OF MY DISMISSING THE TIME AND THE EAGERNESS TO SHOW THEM "ONE MORE THING," AND THEIR INTEREST TO ADD OBSERVATIONS TO THEIR BANK OF KNOWLEDGE. BUT WE DID GET UP BEFORE SHIFT CHANGE. THE HUMOR OF HAROLD WAS STILL IN EVIDENCE AFTER THE LONG CLIMB AND THE HEAT AND SAUNA OF THE MAGMA MINE, WHEN THE MINE SUPERINTENDENT ASKED THEM, "HOW DID YOU LIKE THE MINE?", HAROLD REPLIED, "WELL, I WAS WONDERING IF MAGMA WAS GOING TO RUN OUT OF ORE BEFORE OREGON RAN OUT OF TIMBER!"

AS PART OF HIS BEING, HAROLD GREW MANY KINDS OF FLOWERS AS WELL AS STRANGE THINGS LIKE KUMQUATS AND MEXICAN LIMONS. THESE HE ALWAYS BROUGHT IN TO SHARE WITH THE SECRETARIES. THE QUIET, CONSIDERATE, AND SHARING SIDE OF HAROLD.

THE FINANCIAL STABILITY OF AGS AT THE PRESENT TIME BELIES THE FACT THAT IT WAS NOT ALWAYS SO. HAROLD WAS PRESIDENT OF THE SOCIETY IN 1968-1969, BUT IT WAS SEVERAL YEARS EARLIER THAT DUE TO THE FINANCIAL UNDERWRITING BY HAROLD AND DAVE LOWELL, THAT THE AZ HIGHWAY GEOLOGICAL MAP COULD BE PUBLISHED IN FULL COLOR BY THE SOCIETY. THIS POPULAR MAP WAS ONE OF THE FIRST OF ITS KIND IN THE WESTERN STATES, AND HAS NOW BEEN REPRINTED. A FITTING TRIBUTE TO HAROLD AND HIS BELIEFS IN OTHERS.

HAROLD, HIS LONG SHOES, HIS GAIT, AND HIS ACUTE OBSERVATIONS HAVE LEFT THEIR IMPRINT ALONG THE CORDILLERA FROM SOUTH AMERICA THRU PANAMA TO MEXICO, ALL ALONG THE WESTERN U.S., AND INTO CANADA AND ALASKA. IT HAS BEEN MY PLEASURE TO HAVE INTERMINGLED WITH THE PRINTS HERE AND THERE.

RATHER THAN GOODBYE, HAROLD -- IT'S UNTIL WE MEET AGAIN -- THANKS FOR ALL YOUR GIFTS TO US.

JAMES D. SELL
Dec. 11, 1986

Run 119 TOCs dun Suites

~~Magma – Oregon~~
~~Never an "Ex" Geologist~~
~~Lazy Shoes – next thing he's off to the next place beyond~~
~~Been there before but ..... what did you see.~~
~~Get caught between H & R to let you second off~~
Always current "WSK"
Briefcase big enough for the square blue Rolle ~~Jiffy~~ Wet Pamphlet
Sloven & strange faint ie. green pant, wrinkled shirt etc.
Sunbeams – Nv – Sin Ln → Niagara
Teacher of AZ Geol Map
Scotchgirl all along the cordillera from Alta ~~Canada~~

575

889-7354
573-4546
573-1246
294-9951 open after 8
746-9716 per phone
5

ASARCO

Southwestern Exploration Division

JDS

May 8, 1987

R.L. Brown
New York Office

Obituary Notices
J.H. Courtright

K. Richard and I have gone over the three attached notices and hope you recognize draft "three" of your Economic Geology article

Kenyon would like to use his initials KR as he has done on the E.G. redraft. On the Mining Engineering article, I felt his name should be in full as it also refers to the bibliographic references.

Kenyon and I feel the contributions notice for the AGS Memorial could be added to both the Mining Engineering and Skillings articles, but not to the Economic Geology article. Perhaps, later a note to E.G. could be submitted by AGS-Asarco on the Memorial Fund.

The Skillings notices generally are treated as news items and thus no authorship is noted.

Thanks for sending the articles along to the respective organizations for publication. Naturally, you and the editors may have some changes you feel need to be made.

I'm still working on a career/bibliography list and a longer paper for the Geological Society of America memorial series, but it is slow going through the necessary files.

Kenyon and I thank you again for the input and for getting this moving.

James D. Sell

James D. Sell

JDS:mek
Atts.

cc: K.E. Richard
W.L. Kurtz

OBITUARY To be submitted to Economic Geology

James Harold Courtright

An Appreciation by the Asarco Exploration Staff with Kenyon Richard.

James Harold Courtright, a member of the Society since 1952 died in Tucson on December 7, 1986, at the age of 78. Harold's career in mining and exploration geology occupied most of those years. He began it as a teenager by helping his father drive an exploration adit into a prospect located near his hometown, in Yakima, Washington. His career ended on the day of his death, as he served Asarco as a consultant until that date.

He was educated in the public schools of Yakima and at Sacramento (California) Junior College. He then entered the MacKay School of Mines in Reno, his semesters there were preceded and alternated with long periods spent working underground at various mining camps in order to raise tuition and living expenses.

In 1941 Harold joined E. N. Pennebaker and Kenyon Richard at Consolidated Copper Mines Corporation, in Kimberly, Nevada. There he began his studies and observations of hydrothermal alteration suites and leached cappings which lasted a lifetime and in which he soon became a recognized expert.

In 1945 Harold and KR left Consolidated and joined Asarco's Exploration Department in Salt Lake City. Harold remained with Asarco until his retirement as Chief Geologist of the Corporation in December 1977.

Following his retirement Harold kept an office in Asarco's Tucson Office and consulted for Asarco until his death.

Harold's record of accomplishment at Asarco is legendary. It began in the Leadville District where he drilled out a deposit in the Sunday-Ibex area. The target was relatively deep, and he was plagued with wandering drill holes. Nevertheless, his interpretations were so sound and his sections so good that the resident mining geologist later reported that he rarely had to make a change on any of them from the inception of mining until the deposit was mined out.

Harold then moved to Silver Bell, Arizona, where he superintended Asarco's first porphyry copper exploration effort. When he went to Silver Bell, he was given a drill map drawn up by a famous consultant and told to drill the holes in the location shown on the map. After some mapping, Harold became convinced that the plan given him was a poor one and would have involved drilling mainly pyritic rock. When the New York Office was slow to respond to his recommendations that the drills be moved from areas shown by the outcrops to be pyritic to those shown by the presence of "live limonite" after "chalcocite, Harold moved the drills anyhow, and was rewarded by ore grade intercepts. The file shows that New York was not particularly amused or impressed by the courage shown by the brash youngster, but was impressed by the intercepts he obtained. Thereafter Harold spotted the holes in the "Oxide" area. Meanwhile, KR had mapped and spotted drill holes in the "El Tiro" area. Those two Silver Bell ore bodies then were partially drilled off.

In 1949 Harold's work at Silver Bell was interrupted by instructions to go to Toquepala, Peru, with KR to outline a drilling program there. This time the instructions were less precise: they were simply to chase out a nucleus of 65 million tons of 2 percent copper known to exist. At Toquepala the mapping turned out to be far more difficult. There had been two stages of enrichment, and outcrops over the known high grade contained sparse goethite and jarosite rather than abundant "chalcocite" limonite. Obviously, the outcrops at Toquepala were not read easily. New York on this occasion had required that outcrop mapping be done with plain table and alidade, and provided a young engineer to run the alidade. On the day the engineer showed up, Harold and KR marched to the first outcrop which displayed all the confusing features resulting from the leaching history at the deposit. The engineer reported to his supervisor that evening that he had shown up at the job at 7:30; that he had responded to Harold's signal and accurately plotted the location of the outcrop by 7:45, but that KR and Courtright did not move from the outcrop for the rest of the day; that the only activity he could observe from his station was a fierce argument interrupted only by violent arm waving and by furious periods of hammering on the outcrop. His suggestion to his supervisor was that he not return to the field the following day, but, perhaps, two or three days hence, when he thought there was a possibility that KR and Courtright might have moved from the first outcrop to the second. Obviously, KR and Courtright did reconcile their differences and having worked out the geology, they did lay out a drill program which resulted in the deliniation of 421 million tons of 1.04% copper.

In 1950 United Geophysical Company discovered, having followed up some magnetometer results, high grade skarn type copper ore in the Pima District a few miles south of Tucson. In May 1952 that company sank a shaft in the mineralization but became discouraged about the economics of their find. They invited various companies to examine the properties and to submit bids and in September 1953 made a deal with Cyprus, but without having given any of the companies which had made examinations an opportunity to bid. During the course of the examination, Courtright noted that pervasive alteration in various rock types was exhibited in mine workings extending away from the main orebody. He had previously mapped alteration in a red-colored hill east of Pima and, subsequently, in a similar small hill to the northwest. He concluded that it was possible to hypothesize a large porphyry copper system extending under alluvium to the north and the northeast of the Pima Mine. He recommended to Asarco that mining claims be staked in that area. The New York Office was concerned with the ethics of such a move prompted as it was by the underground visit, and at first refused to allow the staking to be done. In addition, the New York Office would not approve an option of some claims staked by local prospectors which tied on to the northeast of the Pima Mine. Courtright insisted that the ground be acquired, it was arranged with the Pima Mine manager that Asarco would stake and acquire ground. Asarco acquired the ground now occupied by the Mission Mine. Finding the present Mission Mine was not easy. The very large Asarco property was covered by over 200 feet of desert sand and colluvium. It was underlain by altered bedrock, but copper distribution even within the current Mission Pit is very irregular.

A number of wide-spaced, shallow holes in very low grade or nil copper were drilled. Harold strongly recommended that a drilling program designed to scout the entire zone of strongly altered rocks be conducted, but the New York Office was concerned by the almost continuous string of low grade values cut. Finally, an ore grade hole, drilled on a spurious electromagnetic anomaly was drilled, and an orebody grading 76 million tons at 0.9% copper was drilled off. Mission Mine opened in 1961, and the total ore reserve in that mine is now far larger than the originally estimated reserve.

In 1955 Harold did some work at the Bethlehem Deposit in British Columbia which Asarco then had under option. Harold was one of the first to recognize that the disseminated mineralization at that prospect was in fact part of a porphyry copper system, and the drilling program was accordingly adjusted.

At that time Asarco became interested in mounting a scout reconnaissance program designed to discover other porphyry deposits in outcrop. Harold trained a large crew of geologists to map alteration and to read leached outcrops. As this program progressed over the years many geologists participated in a systematic and orderly mapping program which ultimately covered a very large area. The Sacaton deposit now mined out, was one result of that program. Later Harold became Chief Geologist of the Corporation, and before the time of his retirement had traveled to most of the countries of the world where porphyry coppers are found. His last major examination was at Sar Chesma in Iran, where he had trouble with the immigration authorities. His hawk-like nose and his

skin, tanned and burned as it was by years of mapping in many desert areas, convinced immigration authorities in the Near East that Harold was not an American, but a local type disguised as one.

I believe that any of the managers of Asarco's Exploration Department would agree that it was molded on Harold's image. His insistence on detailed mapping of outcrop, and of understanding the basic geologic processes at work in them is still a keystone component of Asarco's exploration philosophy. Every Asarco geologist has been prouder of his association with Asarco's Exploration Department and, in fact, of his profession because Harold was a member of it.

No one ever heard Harold Courtright complain about his tough early years--he simply thought they came with the territory, and regarded them as part of his geological education. When Harold mucked drift or set timber underground, he was not merely mining; he was observing rocks as well as forming opinions about them. Harold loved to play poker and he loved to play golf and he would suggest bets of any size, provided that the size of them did not embarrass his opponents. He loved a contest as he did the exploration business. When he won, he won graciously. When he lost, he lost with great good cheer and figured that the competition was worth the losses. Probably few geologists now entering the mining and exploration business will have the opportunity to work in as many locations as did Harold. Certainly, very few will achieve as much as he did. All who knew Harold wish he had lived longer as they miss him; however, they also feel privileged and happy to have shared a career with him.

OBITUARY To be submitted to Mining Engineering

J. Harold Courtright

An Appreciation by the Asarco Exploration Staff
with Kenyon Richard.

J. Harold Courtright, born in Yakima, Washington, quietly passed away in his sleep on December 7, 1986, in Tucson, Arizona, at the age of 78. Harold was an AIME member since 1941 and was a mentor to many in the local Section.

His early experiences as a miner, mucker, crusher operator, and placer miner, sparked his enthusiasm for the rocks and minerals he was working with and prompted his formal education at Sacramento City College, California, and at the MacKay School of Mines, Reno, Nevada.

In 1941, as geologist, Harold joined E.N. Pennebaker and Kenyon Richard at the Consolidated Coppermines Corp., Kimberly, Nevada. In the Ely District, Harold found a 20 million ton, +4% copper, orebody between Kennecott's Ruth pit and Coppermines' Emma Nevada underground mine, by careful and thoughtful remapping and restudy of old data going back to 1915. This discovery was the first notch in his ore discovery rock hammer.

Harold's past forty-one years were spent with ASARCO Incorporated where he retired as Chief Exploration Geologist in 1978 and continued as Consulting Geologist for the company.

His work and drilling at Kokomo and Leadville, Colorado; Silver Bell, Mission, Sacaton, and Poston Butte, Arizona, all added new notches, as well as the work at Concepcion del Oro, Mexico, the Bethlehem District, British Columbia, and at Toquepala, Peru, among many others.

Papers were published, with K.E. Richard, in the AIME Transaction volumes: "Structure and Mineralization at Silver Bell, AZ"(Vol. 199), and, "Geology of Toquepala, Peru" (Vol. 211).

It was a privilege to have Harold for a tutor and mentor through many phases of exploration. His wise counsel was appreciated and his humorous insight will be missed by many, including his wife Vi and their sons James and Timothy.

Contributions to Harold's memory may be made to the J. Harold Courtright Memorial Fund, c/o Arizona Geological Society, P.O. Box 40952, University Station, Tucson, AZ 85717. The fund is established to support research and field work as exemplified by Harold's life and work.

OBITUARY To be submitted to Skillings

J. Harold Courtright

J. Harold Courtright, 78, died peacefully in his sleep on December 7, 1986, at home in Tucson, Arizona. Harold is survived by his wife Vi and their sons, James and Timothy.

Born in Yakima, Washington, Harold studied at Sacramento (CA) City College, and MacKay School of Mines, Reno, Nevada.

In 1941, he joined Consolidated Coppermines Corporation as geologist in the Ely, Nevada, district.

Harold joined ASARCO Incorporated in 1945, and remained through to his retirement at age 70. At that time Harold was Chief Exploration Geologist, and remained as Consulting Geologist in the Asarco Tucson Office.

The careful and thoughtful work of Harold is legendary and his footprints and hammer marks are left throughout the Cordillera and on many distant outcrops on the Planet Earth.

Harold was a member of AIME, Arizona Geological Society (Charter Member and President), Society of Economic Geologists, Geological Society of America, and a charter member of the Mining Club of the Southwest.

Contributions to Harold's memory may be made to the J. Harold Courtright Memorial Fund, c/o Arizona Geological Society, P.O. Box 40952, University Station, Tucson, AZ 85717. The fund is established to support research and field work as exemplified by Harold's life and work.

ears. The AZ Daily Star, Tucson, Dec 9, 1954 p. B-3

Vi says no flowers please, although Harold enjoyed them very much. He also contributed to numerous charities and Vi hopes you may do the same for your favorite charity as a memorial to Harold.

J. D. Sell

KENYON E. RICHARD
933 E Waltann Lane
Phoenix, Arizona 85022
ph. (602) 375-8248

April 9, 1987

ASARCO Incorporated

APR 16 1987

SW Exploration

Fred Graybeal,
Chief Geologist,
Exploration Dept.
ASARCO, Inc.
180 Maiden Lane
New York, N.Y. 10038

Dear Fred:

Since I began tapering from active consulting some 2 or 3 yrs ago, I've had several surprises. A few of these follow:

I was going to keep in good physical & mental shape, & do constructive work indefinitely. Those ideas were wrong.

I got tired trying to continue proving---I've forgotten what, exactly---it's whatever I've been trying to prove for 60 yrs.

Because I began saying, "I'm retired", a couple of yrs. or so, ago, I've assumed that work (of all kinds for me) would stop. That's been wrong, too.

Work (by my definition: any unpleasant mental effort) lands in front of me, uninvited, at about the same rate as the past 10 yrs. The recent part of the aging experience has taught me at least 2 things: (1) my ideas of "unpleasant mental effort" are much more inclusive than they used to be; and (2) my procrastination capabilities have improved appreciably, recently.

Friends & relatives explain that it is fortunate that I have work to do because it will keep me alert & interested. They are wrong. Work (broad definition) just makes me irritable.

Over the past 40 yrs., with thoughts toward the miss-named "golden years", I've bought a couple of thousand books (some are even educational), & I'd like nothing better than to just sit down & read them. All I seem to find time for is about 1 book a month.

At my age, pushing 72, work is not fun anymore; and talk about cross-purposes, it's hard work to have fun.

I shouldn't sound quite so cynical, I suppose. At least, I'm healthier physically & financially (that is, luckier) than many of the people I know.

The foregoing short list of complaints about the rigors of the aging process is indulged in to set the stage for my alibi: The eulogy for Harold was read as typed--partly--considerable was

1993 Nov
- 1987 April
6 years + 72 perhaps = 78 probably

extemporaneous. But the typing was in note-form, unpunctuated, rough, incomplete. Believing, as you & Dick Brown probably did when you asked me for copies, that it was typed & ready to copy, a number of others also asked for copies.

In that circumstance I was rather forced to do a proper job of writing the partial eulogy.

Any piece I've written in the past has usually turned out to be OK, eventually, after considerable aching, slow re-writing. Well, I've wanted to do a good job about Harold. This has meant hard work/procrastination (together with working hard trying to have a little fun), & the partial-eulogy, in its somewhat revised form, is late.

It's also incomplete. In recent yrs. Harold & I talked about exploration often, but we had to be careful, steering clear of any of our then-current activities. Obviously, with me being a call-girl-type of consultant (always available, etc., etc.), Harold & I could have been (& were, in at least a couple of instances) on opposite side of a row of claim stakes, even though my work was essentially foreign. This means I don't have a record or knowledge of the important details of much of the last 19 yrs. of his work. Jim Sell would know the most about Harold's career since the early '60s, and so should you.

Although it's presumptuous, I've the feeling that people are waiting for me to write obituaries for various appropriate scientific publications & trade journal. Perhaps I'm wrong about that, and some items have already been written. If not, it should be obvious that, without (a) having described episodes within the last third of Harold's career (I was most concerned with the 1st two thirds because modern generations don't know about that part), or (b) without including commentary about his family, what I have written (copy attached) as his eulogy is too long, tho many important early episodes are not mentioned.

Briefly, I simple cannot write about Harold in condensed versions of each episode appropriate for each publication, or whatever.

It is suggested that, if you haven't already done so, get typed copies (a) of Byron Hardie's part of the eulogy, (b) of Jim Sell's part of the eulogy plus a typed copy of a hand written set of notes (Harold's jobs, titles, dates, affiliations, etc.) handed to me by Jim Sell a couple of days before the services. (I revised some of the dates, & I have just looked at a copy showing my revisions. I now note that Dick Brown's name & initials head the 1st of 2 pages; so, maybe the notes are Dick's, & not Jim's as I had presumed.)

Anyway, (1) with my eulogy, rather carefully re-written but inappropriate for any particular means of publication, in total, (2) with Hardie's & Sell's eulogies, and (3) with Jim's or Dick's (?) chronological notes -- all in front of you, you can then lift bits & pieces from each of these sources and, with your own thoughts, put together proper "notices", obituaries, or whatever is required for various publications. Again, I don't see all of these publications now; so much of this may have already been done.

Best Regards,

Kenyon

Kenyon E. Richard

attach. - cc JHC Eulogy by KR

cc. w/attach.
R. L. Brown
William Kurtz
Viola Courtright (4 extra)
James Courtright
Tim Courtright
JHC Memorial Fund Committee:
James A. Briscoe
Byron S. Hardie
Kenyon E. Richard
J. D. Sell
Jan C. Wilt
Gerry Irwin
Frank Hoagland
John Kinnison
John Guilbert
Spencer Titley
Annan Cook
Ken Cornelius
R. E. Cribbs
Paul Eimon
Mike Greeley
Art Hall
Herb Hawkes
Dan Lewis
James Loghry
Wesley Pierce
William Peters
Mary Lou Saegart
Gordon Wieduwilt
Charles Sewell

NOTE: Just after the services for Harold, & at times since, a number of friends asked me for copies of my part of the eulogy. I don't remember just who asked. The above list, then, is only my guess as to a few of Harold's friends who would like to have a record of a few of the more important aspects of his earlier career -- either because they don't know about some of these activities and characteristics -- or, because they do. This is not a select list -- I have extra copies for those interested.

KR

PARTIAL-EULOGY - JAMES HAROLD COURTRIGHT
1908 - 1986
BY KENYON E. RICHARD
SERVICE: December 11, 1986

Harold Courtright worked at his profession of Exploration Mining Geology for 45 years. I was indeed fortunate to have been able to work with him much of that time.

We may capsulize his work-attitude toward his profession during those 45 years with a few simple adjectives: He was steady, consistent, careful, thorough, curious, questioning, thoughtful, critical, persistent, honest, and so on.

To that list four activities and accomplishments are added for emphasis: 1. He was constantly working to improve the professions's knowledge of many aspects of geology in general -- but, of course, metallic ore bodies in particular. 2. He continually functioned as a teacher of the younger ASARCO staff. 3. His thinking and working at his profession always had a solid basis of practicality and accuracy. And, 4. he contributed several scientific papers to his profession.

The point now is: -- despite this impressive and precisely applicable list of true-blue attributes--(it might be an improvement on the Boy Scout Oath)--and despite his slight (to the rest of us) handicap of only limited formal education, Harold was indirectly and directly responsible for putting more discovery and more follow-up drill holes into more major Cu/Mo/Au/Ag ore bodies than anyone had accomplished since the potential commercial significance of low grade/large tonnage Cu deposits was first recognized in the late 1890's and confirmed with substantial cash flows (Ely, Bingham Canyon) about 10 years later.

To the hard-working, brilliant PhD's who might hear or read these words and be nervously comparing their commercial records with the phenomenal one of this Washington farm boy, the most important difference, I believe, was Harold's strong sense of practicality. It was inherited; but you all can get by as ore body discoverers with just knowledge (abundant, diverse and advanced), if you wear out enough pairs of field boots, too.

Harold began, more-or-less officially, his professional career when I had a momentary flash of good sense and good luck, and hired him in '41 as a mine geologist on the Geology Staff of Con. Coppermines Corp., Ely District, Nev.

That Geology Dept. -- founded, 3 to 6 personnel, and headed by Pennebaker in the '20's and late '30's, and strongly supported by local and N.Y. management -- was rare in the industry, as well as being of high quality, for a medium-size company in those years. Pennebaker taught us a great deal -- but, due to his frequent long absences, we learned to teach ourselves. That is, we really had to observe and think for ourselves.

Harold found -- by careful and thoughtful detailed re-mapping and re-studying old data -- back to 1915 -- a 20-mil. T.

ore body extension -- a large tonnage, then -- between Kennicott's Ruth Pit and Coppermines's Emma Nevada Cave-Mine. This was his first entry in the ore discovery column.

The word "exploration" was not yet really in the mining lexicon. That, however, was what we were doing for "Con. Copper" -- traversing intermittently over a fair amount of Nevada and a bit of California inspecting prospects and small mines for ore possibilities. This was in addition to a nice variety of tasks within the Ely (Robinson) District.

Coppermines owned half of this district -- checkerboard fashion. We were: 1. mapping progress in 2 cave-mines and 3 small outlying operating hi-grade Cu and Cu/Wo$_3$ mines, 2. designing drill exploration programs for small as well as larger ore bodies, 3. mapping outlying (fringe) Au-Ag-Pb-Zn-Mn small mines (mostly dormant but periodically active), 4. correcting old erroneous ore reserve estimates (the new ones were made with reference to, and controlled by, available and impinging geological data -- a new concept to local engineers), 5. making estimates of newly discovered ore, and 6. extending mapping 10s of sq. mi. of wild structure surrounding the 10-mi. E-W Ely por. Cu zone itself. A great place to start a career!

It is notable that while in his early teens Harold helped run the family's dairy farm low on the west edge of the Cascades. During summers he and his father back-packed into the Cascades where they had a log cabin beside a Pb/Zn/Ag prospect. With advice from prospector cronies visiting from the surrounding mountains, they drove adits and drifts with hand steel -- very hard work with slow progress. An occasional few specks of Galena kept them momentarily expecting the bonanza. Harold told me that no one in their group really knew what they all were doing or talking about. But he recalled the fascination he personally had for drilling <u>just one more round</u> -- risking being fatally trapped in the mountains by the threatening clouds of the 1st snowfall. It can be said, this was his introduction to what might be termed the successful explorationist's principal motivation: The hard work and real <u>risk</u> are worth the excitement of the an<u>tic</u>ipation of success, let alone exploration success itself.

At the other end -- before the 47-yr. "professional" span -- while in his 20's he worked several years during the big-depression times on road gangs, and as mucker/miner in numerous small mines in Calif. and Nev. Wages were $2.50 to $4.00/day.

Though never clearly specified, I'm sure his occasional story about poker games at various mining camps had a bearing on his being able to accumulate money to attend a college, and later a university. He described a special concoction vaguely resembling a Tom Collins with overtones equivalent to "supercritical" -- i.e., hot, high-pressure water about to flash into steam. In those days a stronger drink was a better drink. This appreciably increased his popularity as a host of poker games. Mostly the players returned to his poker parties for <u>free</u> strong drinks. I suspect, much of the money usually ended in front of Harold at the games' end.

Interspacing the episodes of working as an underground miner, Harold picked up jobs setting up and running small placer mining systems, and he even worked with a small, early geophysical group. That news will shock some of ASARCO'S early geophysicists.

So, the 47-yr. interval is only the professional part. His connection with mining really spanned an additional dozen years.

The headline-writer of the first notice (12/9) in a local newspaper was certainly uninformed when he included the word "ex-geologist". Harold never stopped his geological works. He was doing some work on a consulting job for ASARCO in their office 1 1/2 days before his demise. Although formally retired in '78 (at his own request, incidentally), he continued on a consulting basis working about 1/2 time for ASARCO and other companies during his remaining years.

He never stopped and, as Bill Kurtz mentioned a couple of days ago, in recent years Harold's answers to questions usually were startling. Somehow he always was "up" on the pertinent aspects of the mining business in general, as well as on exploration pretty much world wide.

We were fortunate in that he and Vi joined a table of mutual good friends at the MCSW Hall of Fame Party and Banquet on Saturday evening past. The atmosphere was noisy but Harold and I did have a nice chat about a few exploration projects, particularly regarding a project that a close friend is running. The friend happened by; we cornered him; and Harold asked the specific, obscure question which got us the information we wanted. After all those years it was a great pleasure to me to find that Harold still had the right questions and could get the right answers. That last talk has assumed considerable importance to me because he was in good form until his peaceful demise a few hours later.

Another commentary expressed more-or-less similarly by several the past couple of days has been that, among his peers, none seem to have had negative opinions about him. This solid respect for Harold is indeed rare and complimentary.

Harold disliked sloth, careless work, falsehood, and erratic thinking. He was good at recognizing mistakes, particularly mine, but he didn't derive these notions hurriedly -- and would comment only if things seemed serious. His criticisms, therefore, were valuable to all of us working with him. I often didn't agree, particularly in the field, but I won only a minority of the arguments. I have clear mental imprints of occasions such as him walking into my Tucson Office -- or a mud hut in the Andes, (same situation) -- carrying a letter or a map and saying, "What the hell are you trying to do now, Richard?" Most often I was the boss, but that was not of concern to Harold; so, if he thought I was doing something wrong -- and said so -- I payed attention.

Although his geological exploration work at Leadville contributed importantly to that long on-going project, his work at Silver Bell, beginning late in 1947, was particularly

significant. Persons from the New York and Salt Lake Offices had designed a plan for a few interspaced, angled (very wrong) drillholes to compare with a large number of old churn drillhole assays in the Oxide area of the 7-mi. long por. Cu. system of Silver Bell. Although everyone knew the program would carry thru summer, tents were specified as economical for geologists several churn drillers, engineers, cooks, etc. The rest of the plan contained similar mistakes for an exploration camp in the hot desert.

While the local manager was not paying attention (the access roads from Tucson were a maze), Courtright: 1. developed a substantial water supply from a minor seepage; 2: wrote workable agreements with a couple of contractors who had successfully completed the San Manuel ore body measurement churn drilling; and 3. built a camp comprising 4 Quonsut huts with evaporative coolers. All of this was adequate for 15 or more men to obtain accurate drillhole samples and reduce them to pulps, to permit careful re-surveying and re-mapping of the Oxide and El Tiro ore zones and large portions parts of the remaining mineralized zone and to plan a continuing drill program. This work was the basis for the Oxide mine preparation and 7500-T. mill construction. Production began in 1954 at a capital cost of $21 Mil. -- at that time, surprisingly, it was the largest single authorization ever made by ASARCO. New York was quite worried, but they were anxious to get into the Cu business. The market was favorable, and the cash flow returned the $21. Mil. in about a year! (Thereupon, New York ASARCO personnel collectively became experts in por. Cu. enterprise financing.)

If the basic sampling job had been done with all personnel working and sleeping in tents in summer at Silver Bell, and the comparison testing had been done by angled diamond drillholes, I doubt if Silver Bell would ever have evolved successfully. Harold's quiet setting up of decent (about $40,000 above planned cost) exploration facilities insured accurate samples (the basic data); and to a degree, he made the mine go, probably at the risk of his job.

In mid 1948 I had mapped the Silver Bell El Tiro area leached capping, outlined the possible area of chalcocite ore and spotted a number of drillhole locations. During that time the assay results of the first couple of Quellaveco drillholes were at hand and were poor. I was worried. Later that year I made my second trip to Quellaveco in the high mountainous desert of S. Peru. By then the drillhole results there were better and so was my nervous system. (The prior year I had recommended and specified a substantial and -- in that environment -- expensive drilling program.)

What with a continuing improvement in Quellaveco drilling results, and the favorable outcome of the Toquepala lawsuit, instead of being fired or otherwise down-graded because the first 15 or 20 Quellaveco drillholes were much lower in value than I'd predicted, I was told in early '49 to do a mapping job and recommend drilling, or whatever, at Toquepala. And -- yes -- I

could invite Courtright to accompany me even though the drilling he was supervising at Silver Bell was now moved to the El Tiro area and was not completed. I had already made (in 1947) a forbidden, fast one-day traverse of Toquepala, and I knew the geology would be difficult to decipher. So -- I was much relieved that Harold's participation would tend to prevent any near-disaster such as my over-enthusiasm almost caused at Quellaveco.

Aside from plain hard work for 7 months and the difficulties of mapping geological features, many of which we had never seen or heard of before, and only gradually had begun to understand and agree upon, there were so many unusual aspects of the job that I can really describe very little here. The details, not the outline, make the story -- there isn't time --.

For one thing, I could never have properly done the job by myself or by working with anyone except Harold. His insistence on both of us returning time after time to certain small areas of outcrops of uncertain interpretations, resulted, eventually, in several significant conclusions. Without these concordances, the on-going and subsequent Toquepala drilling program could have lost a wheel.

The final report and maps were good, due largely to Harold's patience and persistance that we agree and be as nearly correct as we could manage.

Though there were many, one episode is memorable: We had been working day and night for 3 months; we had footprints all over about 50 square kilometers; and we had not really put much of anything together with certainty. New York didn't know this. (Lack of communication with headquarters sometimes can be a many splendered thing.) So, they had decided, somehow, that we would be finished in three months; and drills and drillers began to arrive then. Because we were uncertain where, or if, a lot of holes should be drilled, we had built only one short drill road. (Using trails 9 years earlier, Cerro had drilled over 30 diamond drill holes in a cluster -- almost all were hi-grade -- all averaged more than 1.3% Cu -- the Chalcocite was 400' thick and avg. 2.0% Cu -- with the best hole averaging something like 490' @ 5.0% Cu.) We had to start drilling. Despite having all of Cerro's drillhole information, we spotted the first 2 holes in waste -- right in the middle of 400 mil. T. of ore! It was practically impossible to do such a thing -- but we managed.

Before any of the chiefs learned what we had done, and before anyone could get there from New York, we had gotten our act fairly well together and had several holes in ore. The two waste holes were mostly unnoticed.

Beginning somewhere along in there we were moved, unnoticeably, onto the "up" escalator by ASARCO Chiefs.

(Those organization escalators are wobbly. I nearly toppled a few times in the '50s and early '60s in situations when Harold didn't happen to be involved and would have asked, "What in the hell -- etc. -- Richard", and get me off my tangent.)

The Mission project was so complex that about all I can

remember is trouble. Someone said he heard Harold answer a question by a geologist of the competition: Something as to what parameters had we set which resulted in the Mission ore body discovery. Harolds reply was, "1. it had to be close to Tucson; 2. but not too close to be complicated by real estate developments; 3. not too far out so as to be a bothersome drive from the Tucson Exploration Office; 4. within 4 mi. of a major power line and highway; and 5. an assured water supply had to be within 3 mi. Then we start to drill."

It certainly wasn't as simple as that, but the foregoing parameters given facetiously by Harold became apparent after, not before, the fact. That is, the ore body was gradually discovered and, during that procedure the actual existence of Harold's parameters were noticed, casually. To a certain extent that is a good technique. (Just put up the single idea; "ore body -- any kind" as a parameter [unlimited], and begin an exploration program). Many good "ore" bodies doubtless remain undiscovered because they are just outside of the sets of parameters mistakenly, but commonly, put together by many as the proper "step one" for any exploration program.

To continue with Mission: after Harold's original recognition, described below, we started drilling thru a sand pile 200' thick. Fifteen shallow holes spaced at 2000' were drilled into bedrock a few feet. All bedrock core was found to be altered and mineralized -- mostly leached, but some shallow sulphides, and a few assays of mixed ox./sul. about .1 to .2% Cu were obtained. The 16th hole had a column of ore-grade cpy. -- about 100' avg. 1.5 Cu. Although we now had a known large por. Cu-type alt. zone which probably contained an ore body somewhere, we still didn't know just where it was. We continued to stumble around, and after about hole 50, results began to seem like we were into an ore body -- very tantalizing; so -- we just kept moving drill rigs around in the sand pile -- and the Mission ore body emerged from the mist of numbers and ideas.

Harold started all the foregoing which evolved into the Mission, S. and N. San Xavier etc. ore bodies:

United Geophysical, then owned by Herbert Hoover, Jr. and Henry Mudd (grandson of the famous "Seeley" M. who drilled all those 150-odd churn drillholes the length of the Silver Bell Dist. in the early "teens" of this century -- a real "explorationists" of his time), with Robert Thurmond and Walter Heinrichs, proteges of Art Brant of Newmont, supplying the technical theories and field techniques, had made a legitimate magnetic geophysical discovery under the 200' sandpile at its western edge: a few drillholes cut a bed of magnetite/chalcopyrite 10 to 20' thick dipping S. about 50° and assaying 4.% Cu. The vertical Pima Shaft was sunk 650' in the footwall of the ore bed -- levels about 220', 400', and 600', and drifts along the ore bed for about 600' - 800'.

Harold got into these workings, accompanying several ASARCO and Pima supervisory personnel (formerly United) in early '53. On the 400 level (below any oxidation or enrichment effects) he

noticed a crosscut due S. into the hangingwall of the E-W. ore bed. With the customary stealth we all use in such situations he quietly disappeared into that crosscut for some 200'. Beginning at the ore bed hangingwall he was in garnetized limestone carrying disseminated chalcopyrite, and within a few feet he was in rock (later identified as arkose and other clastic sediments), all strongly altered to fine-grained quartz/sericite ("phillic" not yet invented) and mineralized with disseminated py. and cpy. As he walked and chipped the wall the length of that crosscut, several chips happened to fall into the pocket of his field coat and from there, unnoticed, eventually into ARASCO's assay lab. These chip assays ranged .5 to 1.0% Cu. -- and that's when things began happening.

We knew, as a result of work in Ely, Silver Bell Toquepala and other por. cu. districts that much so-called por. Cu ore occurred in sediments and many rocks other than porphyry, a simple fact overlooked, then, by most others in the exploration business. Even before the chip assays were in hand, Harold knew that crosscut was in lo-grade "por. Cu" ore-grade rock. Pima's technicians hadn't sampled the crosscut, not had they assayed any samples from the many nearby vertical "rotary" drillholes as they cut through altered rock on the way to the "ore" bed which they core-sampled. Pima's technicians flat-out missed the disseminated chalcopyrite in the altered sediments; they had no idea they were drilling through a por. Cu-type ore body! They had only a half dozen claims covering the sub-outcrop of their ore bed. For many square miles E., SE., & N. the region was alluvium-covered, and mostly unclaimed.

An exception: a half mi. E. of their Pima shaft a low hill about 400' in oval length comprised the leached, altered/mineralized quartz-sericite clastics rocks like the S. cross-cut of Harold's original sample fragments. Sparse specks of limonites-after-Cu-sulfides indicated that lo-ore or sub-ore-grade rock of por. Cu type persisted as least that far from the Pima shaft. An old 50' adit had been driven into that hill where a small patch having a faint glaze of green Cu silicate, the prospectors' and many others' mistaken guide to Cu ore, could be seen. At least, the early prospector's adit represented some recognition of ore possibilities. Pima people (originally "United", then Pima, later "Cyprus" and now, finally ASARCO) ignored the mineralized outcrops by eventually covering the east end of the hill with the head-end of their mill.

> (I recall the dump from that prospector's adit, particularly, because as Harold walked off the shallow edge he stepped on a rattle snake. Poor snake! Those famous custom made, thick-soled size 14 1/2 Washington loggers boots.)

With the permission of Pima's local manager we promptly staked about 3 square miles of claims and bought a few illegally staked prospectors' claims. For this, as we learned later, the Pima mgr. quietly spread the false idea, after we had drilled the

Mission ore body, that we were grossly unethical for staking all those claims. He never admitted to any of his local staff or to his had office in L.A. that he had given us permission to locate those claims. (Actually, if left to our own devices, Harold and I would not have bothered talking to the Pima mgr., but ASARCO N.Y. insisted.)

He (and his company) deserved to lose several 100 Mil. T. of ore, which is just what happened to them.

The story goes on and on, and it became even more frustrating at times -- but I'll stop here, and remind you that it was Harold's sneaky way of sampling that crosscut that caused the discovery and development of all those huge, "eyesore" mines and dumps S. of Tucson -- near a main highway -- power -- a railroad -- etc., etc. -- and which, to date, have enriched the world's supply by several $ Billion worth of Cu/Mo/Au/Ag.

While carrying on the Mission program of drilling through the 200' sandpile, guided by frequent visits from various soothsayers and prophets for inspiration (their receipts did look funny on our expense accounts) and with the drillhole assays looking more and more like we had an ore body, we incautiously leapfrogged a long jump with a drillrig northward to a willy-nilly location within a few feet of the south, E-W-trending border of the San Xavier Indian Reservation. Naturally, that drillhole cut a nice long column of good ore. (Full credit for that one goes to the gypsy with the marked deck of Tarot Cards.)

Somewhat prior to then Harold and I had seen a small hill in the middle of several 100 square miles alluvium on the Reservation on various flights. (We were aggressively looking (by small plane, by jeep and by foot) for alteration zones of disseminated leached sulfide type) by traversing the SW. from '53 on --.) The small hill seen on the Reservation didn't appear altered (the flights were too high); so, we put it in the "we'll look at in on the ground -- sometime" category. After drilling that ore hole just S. off the Reservation, Harold found the hill by much criss-cross hiking -- the somewhat thick desert brush and flat terrain hid the hill until he practically tripped over it. The hill comprised clastic rocks altered/mineralized to quartz-sericite-clays (just like the important-clue, ore-guide hill E. of the Pima sh. -- except this newly-found hill additionally was cut by a dike of "typical" porphyry -- all formations contained sparse dissem. specks and veinlets of limonite-after-chalcocite!) Because the hill showed no trace of green Cu-stain, it had no evidence of ever having been chipped or sampled, even tho it was only a couple 100 yards from an Indian cattle "tank" reached by an obscure road. The outcrop limonites indicated only sub-ore-grade pre-leach rock, the hill was certainly a very hot por. Cu prospect about 2 1/2 miles N.N.W. from the good border drillhole at Mission. Also, Harold found a small outcrop of a postmineral conglomerate containing boulders of leached, alt./min. porphyry covered by an expanse of sand and gravel some 200' thick, and the exploration odds were very favorable ("sugar plums dancing ...") for the occurrence of one or more buried ore bodies on the

Reservation.

Of course we quickly began investigating the matter of obtaining some kind of exploration mineral rights on the Reservation. It was soon evident that no one, including ASARCO's mining lawyers and the U.S. Bur. Indian Affairs, local (Sells) and national, knew how to go about obtaining (or granting) these rights.

What with as many as a half dozen diamond drill rigs clustered so close to Tucson and just N. of the Pima mine (by then a relatively small open pit mine and mill were being designed there), the exploration competition (mostly newcomers -- but both old and new companies) were buzzing around our drilling operations in small planes daily. It would have been no problem, just with an occasional batch of snapshots, to guess what we were finding with the drillholes.

As were trying to get commitment from the Bureau of Ind. Affairs, et al., many of our explor. competitor companies were beginning to follow our tortuous traverse through the same bureaucratic tangle. Finally, it was decided by someone in the Ind. Bureau with more authority than knowledge, that, because so much interest had evolved (the Bur. told us they had had several dozen separate inquiries) from the mining industry, the 30 square miles we had first indicated several months earlier to be of interest to ASARCO for exploration would be put up for auction soon, with a lease, 10% royalty, etc., etc., for the high bid.

Instead of "soon" the deadline date for receiving bids eventually was set for several more months ahead. Our Mission drilling was continuing, with obvious success to any exploration group paying any attention. So, as the time before decision on the "amount" to bid became protracted, the greater became our (local) anxiety about the competition; and, concomitantly, the "amount" we thought would be needed to win grew exponentially.

We got wind that the N.Y. ASARCO Chiefs (Mining Dept.) were thinking in terms ranging within $20,000 and $250,000. They had never before been confronted with an auction situation, and they really didn't appreciate our opinion that the alt./min. small hill represented excellent odds that an ore body was buried nearby. This was serious. We had learned that the real excitement in the exploration business was in assuming responsibility for big exploration risks (not in the sense of poor odds, but in big payoffs). So, without being invited, we volunteered that a bid of $3/4 Mil. should be made. ASARCO's Chairman decided that, because Harold and I were closest to the problem, he would back us by making it an even $1. Mil. -- and insofar as the low-bid N.Y. crowd was concerned, that ridiculous bid was our fault!

The day of the bid-opening at the Sells Agency there was quite a bunch of exploration companies amply represented. We were indeed dismayed, however, to note that when the dust had settled -- only -- 3 -- bids -- including ASARCO's -- were on the table! Gov't officials fooled around awhile, obviously expecting more action. (I was about to throw up.) They finally opened one

bid -- it was for $10,000! Harold and I almost died. The second bid was from a small company with no money -- but they'd found an angel. Their bid was $365,000. -- and we began to breath again though I've since wondered if oxygen shortage may have damaged some brain cells. That poker bet by the small company was large enough to make ASARCO's $1 Mil. gamble legitimate.

After that nerve-rending episode, many legal hurdles still had to be jumped. But once we were able to drill, we didn't stumble around very long before the drills were penetrating 2 ore bodies; one just inside the S. boundary of the Reserv. and the other near the small hill. Although, of course, I'm not privy to exact numbers, I think something around 200 Mil. T. of ore (partly mined) has been found on the Reservation -- to date. Not bad for a small (immense, at that time in the mining industry) bet of $1. Mil. Again success was due to Harold's persistence in finding the alt./min. hill & the conglomerate.

There is so much that I would like to say about Harold's professional pride and accomplishments -- but there isn't time here. So much must be left out. In that circumstance, I'll tend to omit the mistakes and touch the modest failures lightly.

Posten Butte, found by John Kinnison near Florence, is one project I'll describe only briefly. It was technically beautiful -- only a few square feet of typical (but weak) por. Cu alt./min. outcrop remained uncovered at an alluvium/post-mineral volcanic contact. I'll never forget standing on that spot with Harold and some N.Y. Office mining engineer-type mgrs. and a V.P. and pointing out across the flat alluvium plain (it extends for miles in all directions) to a drilling rig, 3/4 miles distant in the middle of an 80-acre cotton patch, pulling out core running 1.5% Cu as chalcopyrite in alt. por. <u>That</u> was fun!

However, although 25 drillholes indicated an alt./min., Cu-bearing zone some 2 1/2 square miles in area, the values were inconsistent from hole to hole. It is very difficult to decide to stop a project -- they develop a certain momentum. We decided, however, to walk away from it.

> (Some years later under better economic conditions, Harold sent men up to see about re-acquiring the properties and claims we had earlier dropped. The action was a week too late. Another explor. company had acquired the best half. ASARCO took the remainder and drilled a few more holes, with inconclusive results as I've heard, and eventually dropped it again. It could be guessed that including both episodes, ASARCO was out, say $1/2 Mil. The other company, though, really couldn't stop. Many deep drillholes, a shaft and underground comparison sampling, a pilot mill (modest?) -- an unfounded but reasonable rumor of a total cost of some $15 to $20 Mil.! This should have given them some practice in learning when to stop.)

Sacaton was another discovery of an alt./min. granite and por. hill, about 200' by 300' oblong, surrounded by hundreds of square miles of sand and gravels ranging within depths of a few feet to hundreds. It was about 6 mi. NW. of Casa Grande. Again, lacking green copper-stain the small hill showed no evidence of any chipping or digging by prospectors or geologists -- but it carried sparse amounts of limonites-after-Cu-sulfides. This hill was different, however, because Kinnison predicted its position before he found it.

During the latter '50s a mostly erroneous theory that por. Cu ore districts occurred at major fault intersections gained such false credence as to become a fad. Large numbers of devotees, many of whom should have known better, were criss-crossing Arizona, N. Mexico and N. Sonora with (mostly) straight lines, and talking about drilling the intersections all over the place. The basically weak part of the theory was that major faults were the key: but, for heavens sake, most of the faults used for these lines, or "lineaments", were post-mineral.

Before accepting work with us Kinnison had made a "lineament" map of a portion of Arizona as an exercise for one of his graduate seminars at the UA. After working with us for awhile, he showed us the revised sketch with emphasis (supplied partially, I think, by casual opinion by Harold and me) more on "aligned" (a) known alt. zones, (b) porphyries and other similar intrusives (all small), and (c) known por. Cu districts. As I recall his lineaments were bands rather than the mistaken structural "planes" used by most hobbyists of this fad; thus, his analysis had validity. He favored an area of intersecting bands NW. of Casa Grande. He left the next morning, expecting to "scout" the area for several days. Within a few hours the next day he called describing another alt./min. hill he found -- right in the center of the intersecting bands of his sketch.

Nearly 30 years later, after one small open pit ore body has been mined out and 3 deeper ore bodies have been drilled, it is notable that no pre-mineral planar structures have been recognized which could have had any structural control on the lateral position of this major, buried por. Cu system.

Harold's next contribution (besides comments which aided Kinnison) to that project was crucial: ASARCo's Chairman decided the company was suddenly too poor to gamble. A good many lines of several geophysical systems had been run over a large area, but the only anomaly was a small IP. kick around the alt./min. hill. We had recommended diamond drillholes to test this anomaly "as a beginning". The chairman told me emphatically that unless we found something good, 6 holes was all we should get to drill.

After 5 drillholes in the anomaly around the hill, each showing only a few feet of sub ore-grade chalcocite-bearing rock, and nothing offering immediate encouragement, the location of the last hole was indeed critical. We knew at least another dozen wildcat holes was warranted; but the chairman didn't, and no one else in N.Y. was helping our cause. Harold and I agreed we should move outside the anomaly with this last drillhole. I

wanted it several hundred feed ENE. along the projection of the oval trend of the anomaly: Harold, N. of the anomaly. As so often the case, Harold's logic prevailed; and our last-allowed wildcat drillhole cut a nice column of chalcocite/chalcopyrite ore in por., the first drillhole in the 50. Mil. T. Sacaton open pit ore body. At least 3 other underground "ore" bodies, now sub-commercial but eventually to be mined, are known. So., its a major district -- that small hill was the tip of a huge ice berg. And, if Harold's location for the final drillhole had not prevailed, it all would still be unknown.

During a good portion of the times we worked together I was the boss. In terms of the decision-making process that situation didn't concern Harold very much; nor, for that matter, neither did I pay any particular attention as to who get credit for which mistakes, or what. Others within the company to whom it was of some importance, for whatever reasons, knew pretty well, it seemed to me, who had done what. All in-the-field recognition of certain important geological conditions which lead to discoveries, or near misses, or whatever were made by Harold, or by other geologists who were using observational or other techniques taught them by Harold and/or me. My contribution was quickly to look over these discoveries, usually with Harold, and if we both approved, to telephone, to write letters and reports giving proper credit to who recognized what -- all of which was done to get as much exploration money authorized as we thought we could get by with. Briefly, as the boss my contribution was my neck (and I particularly enjoyed that part actually -- it made the whole game more fun). What with these reports and such, my name usually became so closely identified with the early phases of a project that, if it became a real discovery, I was often mistakenly credited as "the" discoverer. At the time of any particular instances I usually was unaware this was happening, and did not realize that such was the case until maybe years later.

Beginning about '50 when real systematic exploration by <u>groups</u> of explorationists evolved, and continued to the present, hardly anything was discovered (in the true sense of quick recognition of key geological features) during the past 4 decades by <u>any</u> individuals all by themselves. (Lowell's Kalamazoo was an exception.)

I <u>was</u> aware, and tried to correct things when I could, that outside of ASARCO, but locally, I was getting undue "discovery" credits. It wasn't until I resigned from ASARCO and undertook foreign consulting out of Tucson that I gradually realized (both friends and casual acquaintances talked more freely, what with the ASARCO severance) that the mistaken idea that I had done most of the "discovering" was rather pervasive through the industry. Though fine and dandy for my consultant reputation, this situation generated some personal guilt because (a) Harold and/or our field geologist had made most of the critical basic, original field interpretations, and (b) Harold had argued sufficiently to prevent me from making a good many serious exploration mistakes.

I had been given an undue amount of credit for discoveries. Yet, there was little I could do to put things right except, when the subject might by happenstance come up in stray conversations, I would try to explain who actually had done what. These efforts didn't accomplish much because I could usually discern that the audience, whoever, was wondering why I was undertaking such an uncharacteristic display of modesty.

Anyway, in my opinion Harold's persistent exertion of pressure on me to keep things more practical and sensible made me somewhat famous as an ore body finder. It seems pretty well understood that we were jointly involved in a number of exploration projects which turned out well. Though we both get credit, a goodly portion of the credit given me should have devolved upon Harold.

12/8/86

FROM: W. L. KURTZ

TO: Mary

Will you handle?

(1) Please make inventory of reports sent to Mrs. Cockright; don't send until I know

(2) Reports not elsewhere in our files as I may want to have copies made for our files.

WLK.

I have noted & highlighted things I think we should keep we have in our ASARCO File and/or be pulled.

JKS
5/10/87

7-8-86

J.H.C Personal data at ASARCO office which should eventually be retreived and stored in home office.

1. Desk file: right hand lower file drawer.

2. Contents of top 3 drawers in gray-brown cabinet in NW corner of office.

3. All reports (authored or co-authored by JHC in report files in basement.

W.L.K told Mrs. Cartright (actually Kenyon Richard) that he would see that the above are delivered to her.

J.H. Courtright Desk File - Item 1 on list

Retainer
- Consulting Services Invoices JHC 1977 thru 1986
- Ltr to JHC from TCO 12/1/77 "Retainer" and renewal letters from TCO 5/11/79 & 5/2/80, and from RLB 5/14/81, 5/12/82, 4/22/83 & 5/21/84.
- Ltrs re L.P. Entwistle "Retainer" 1975
- Ltr to FTG from TCO 12/8/77 "Harold Courtright"
- Ltr to TCO from JHC 4/22/77 re Post-retirement
- Ltr to TCO from JHC 11/15/77 on his background
- Asarco News release on JHC retirement

Beeder, John
- Failure of Mining Operations Causes and Costs by John Beeder, date stamped by JHC 9/2/80

R.L. Brown
- Asarco News release - election to VP 4/26/82
- Article, Note
- Ltr to RB Sprague from RLB 3/17/76 re Saudi Arabia
- Report "Copper Supplies Into the Next Century" by Richard L. Brown and James H. Courtright 12/22/80

CADWELL, D.P.
- Notes

Collins, J.J.
- Ltrs re JJ Collins retirement 1975

Eimon, P.I.
- Paper by PI Eimon, May 1981 "Exploration for Epithermal Gold and Silver Deposits: The Epithermal Model"
- Ltr to WLK from PI Eimon 9/18/81 re field visit
- Notice from Commonwealth International - PI Eimon, Pres.

Dickerson, Ben - Management
- Report by Ben F. Dickerson "Random Observations on the Facts of Mining Life"8/2/8
- Management Lessons - "And we learned about Exploration Management from That" by Ben F. Dickerson III

Gilmour, Paul
- Memos re visit to Silver Bell 1983

Graybeal
- Article of FTG
- Memo from FTG 1/30/81 "Paper on Disseminated Silver Deposits"

Robt. D. Hoffman
- "Diary of Robert D. Hoffman, the Rouyn Rush, Dec. 8, 1922 - to Jan. 11, 1923, The Spring of 1923, How I tied up with Quinny Shaw"

Jenny, C. Phillip
- Speach - date stamped by JHC 3/30/77

W.R. Landwehr
- Notes, Articles
- Booklet - "Belts of Major Mineralization in Western United States" reprint 1967
- Booklet "The Genesis and Distribution of Major Mineralization in Western United States" reprint Dec. 1968
- Mining Journal article Jan. 1942 by W.R. Landwehr "Geological Factors in Recent Ore Discoveries"
- Ltr to Dr. Edwin B. Eckel, Sec, GSA, "Re Memorial to W.R. Landwehr" 2/11/72 w/att

T.C. Osborne
- Asarco News Release on TCO - VP Expl. 5/12/78
- Ltr to WLK from TCO 7/1/76 "File Information"

Pennebaker, E.N.
- Reprint August 1973 by EN Pennebaker "Geologic Factos in Metal Mining Mergers and Unitizations"

Richard, K.R.
- Various articles by K. Richard
- Reprint July 1956 "Geologist-Metallurgist Cooperation in Porphyry Copper Exploration" by KR

Smith, Doug M.
- Ltr to JHC from DMS 5/17/78

Sprague, R.B.
-"Proposal for a prospecting program in Europe, concentrating on Spain & Portugal. Resume of experience attached" by R.B. Sprague, date stamped JHC 12/3/8

Strauss, Simon
-"Metals 1980" lecture AIME Tucson

AMAX-ANAMAX
- Articles & notes

Anaconda
- Articles, Shareholder's letter 9/15/76

ASARCO #1
- Articles, Asarco News releases
- Memo to JJ Colling from JHC "Estimated Life ASARCO Properties" 2/14/75
- Ltr to WS Paley from CF Barber "CBS Reports documentary: "The American Way of Cancer" 11/14/75
- ASARCO Policy Statement from TCO 9/27/76 on Political contributions
- "Report of 1976 Activities" Asarco PAC

ASARCO #2
- File - Stockholder info, Stock Broker Rpts. and talk by Charles F. Barber at NY Society of Security Analysts 6/16/72

ASARCO Properties Estimated Life
(Empty folder)

Callahan Mining Corp
- Copy of Airline ticket & hotel statement

Chevron, Exxon, Union, Crane
- Memo by JHC 12/17/76 "Chevron"
- Memo to RLB from JHC 4/20/77 "Crane, Exxon, Chevron, Union Oil"
- Memo to JHC from FTG 4/19/77 Re C.F.& I.
- Memo to JHC from G.W. Pickard 4/18/77 "Review of Annual Reports Crane, Exxon (N.J.Std & Humble Oil)

Cont. Materials
- Article
- Continental Materials Corp. 1974 Annual Report

Earth Resources Co.
- E.F. Hutton Update of Earth Resources

Freeport
- Article

Homestake (Napa Co., Calif.)
- Article

Kennecott
- Articles

Newmont
- Articles

Phelps Dodge
- Articles, Prospectus, Bond issue

Placer Development
- Article

AIME
- Forms, etc.

AIME Ariz. Meeting - Dec. 76
- Memo to JHC from RLB 3/4/77
- Memo by JHC 12/27/76 - AIME Arizona Mtg. Dec. 6, 1976 w/atts.

Arizona Geological Society
- Notes
- File 1958 to 1976

AGS Field Trip - November 1977
- "A Field Guide to Certain Massive Sulphide Occurrences in the Precambrian of Central Arizona" AGS Field Trip 11/19/77

AGS Symposium - 1976 - Mar.
- Notes
- "Thirty-Year Evolution of Porphyry Copper Exploration in Southwest USA - Part I- Techniques and Philosophies" by Kenyon Richard, AGS Seminar, April 1976
- "Case Histories of Discoveries" by J.David Lowell, date stamped JHC 3/22/76

Accounting - Expl.
- Accounting Instructions Circular Letter 10-76 "Mines" from Robert Richter 12/1/76

Administration
- Organizational memos 1969-1977

Age Dating
- Articles
- Isochron/West - No. 17 Dec. 1976
- Ltr to Paul E. Damon from JHC 2/7/64 "Isotopic Dating of Arizona Ore Deposition by Richard L. Mauger and Paul E Damon.

Air Schedules
- Air Itineraries

Analytical Labs
- Brochures & Price Lists

Arizona Cu Mines - Reserves & Prod.
- Tables 1981 & 1982

Arizona State Board Tech. Registration
- Forms, memos, certificate, etc.

Arsenic
- Article

Arizona Active Mines & Exploration Companies w/offices in Sou. Arizona
- Directories & Corresp. 1956-1977

Awards
- Memo to Guy McBride from JHC 2/13/75 "Spencer R. Titley"
- Ltr to JJ Collins from James S. Hastings 5/21/74 re Distinguished Achievement Metal from Colorado School of Mines.

Asbestos
- Articles & Memos

Assaying - in hole
- Memo from JJ Collins 3/6/75 "In-hole Assaying"
- Memo from CK Moss 4/25/75 re in-hole assaying

Barite
- Article

Bauxite
- "Bauxitization in the Pocos de Caldas District, Brizil" by Benjamin N. Webber Aug 1959
- "Beryllium" by Burton J. Devere 9/1/78 "Beryllium"

"Black Smokers" NW Pacific
- Memo to JDS from FRK 1/9/85 "AGS Task, Sulfide Deposits on Oceanic Spreading Centers."

Block-Cave Outcome
- Ltr to JJ Collins from WLK 6/9/72 "Block-Cave Outcome"

Breccia Pipes
- Mineralized Volcanic Explosion Pipes by R.T. Walker 1928
- Notes on "Diatremes and Certain Ore-bearing Pipes" by W.H. Emmons, May 1938
- Memo to JDS from FRK 2/22/83 "Cornflake Breccias-Exploration Potential, Treasure Hill (SE/4 Sec. 6, T11S,R2W) Tintic (South) District, Juab Co., Utah"
- "Process of Formation of Mineralized Breccia Pipes" by Kenyon Richard
- Report "The Original and Significance of Breccia Pipes" Henry T. Eyrich, 1/5/71
- "Shock Brecciation, An Unrecognized Mechanism for Breccia Formation in the Porphyry Environment?" by Colin I. Godwin, 1972
- "Intrusive Breccias, Fluidization and Ore Magmas" by Donald G. Bryant from 1974 Mining Yearbook

Certainly should be in ASARCO File before sendinsto Vi.

Case Histories - Ore Discoveries
- Ltr to Victor F. Hollister from RLB 5/6/83 re draft Norman Kesten's paper on Galena Mine
- Ltr to RLB from V.F.Hollister 5/3/83 re AIME volume
- " " JHC " " " 6/9/83 Re Sacaton Arizona
- Memo to FTG from DMS 4/6/83 "SME Ore Deposit Discovery Book"

Catalytic Converters
- Article

Caulderas - Collapse Breccia
- "Caldera-collapse breccias in the western San Juan Mountains, Colorado" by Peter W. Lipman 1976

Ceramics
- Article

Chromite
- "Chromite" by JHC 4/5/72 (Listing)

Columbuim
- Note on St. Laurence Columbium & Metals Co.

Company Policy
- "Policy Statement Conflicts of Interest" 8/26/75 from JJ Colling
- "Obligation of a Corporation and Its Directors, Officers and other Employees with respect to Confidential Information concerning the Corporation" May 27, 1965

Competitive Activity
- AIME - Atlanta - 1977 by FTG

Consultants
- Business Cards, Resume's, Price Lists, Memos on Consultants

Copper - C.F. Barber
- "More About Copper - Reflections on Fundamentals in the Interdependent World of the 1980's"

Copper Data - Am. Bureau Metal Statistics
- Statistics on World Copper

Copper
- File Memo JHC 11/1/84 "Copper"
- Remarks by TCO 7/26/84 "Asarco's Cost of Mining Copper"
- Articles, Notes, Calculations
- Remark by Charles F. Barber 12/8/83 "Economics of Copper in the Mid-80's, A Role for the Multilateral Financial Institutions."

Copper Metallurgy
- Articles
- Annual Research Meeting, October 4, 1973, Agenda

Copper Outlook - North America
- Memo for JJ Collins 8/25/72 from JHC"Copper Outlook-North America"
- "Copper Production of Large Arizona Copper Mines" Years 1970 and 1971
- "Recent New Canadian Open Pits" date stamp JHC 11/21/73
- "Capital Costs per Ton & Per Lb Recoverable Cu" date stamp JHC 11/21/73
- "Capital Investment-$ Per Annual Ton of Copper Production-Open Pit" date stamp JHC 1/9/73
- "Hypothetical Estimation of Deep Block Caving Income"
- "Hypothetical Deep Block Cave Cash Flow After Tax"

Costs of Production - Metals
- Notes, calculations
- Ltr. to JJ Collins from LP Entwistle 9/5/75 "Open Pit Gold Mines, Getchell Mine"
- Memo from CF Barber 8/5/75 "Re: Cost to Market Copper"
- File Memo from RL Henneback 3/4/74 re Construction Cost & British Columbia Royalt
- Memo to CF Barber from JJ Colling 7/10/75 re Ore Targets

Construction Costs - Capital
- From WT Sweat 12/28/82 "Engineering News-Record, Construction/Building Index
- Engineering News Record, Construction Index, Building Index - received stamp by AJ Kroah 5/26/76
- Scehdule Feb. 79 - Companies & Capital

Copper Prod. Forecasts
- Articles, Notes
- File Memo from JHC 2/16/79 "World demand for Raw Materials in 1985 and 2000 by Wilfred Malenbaum"
- Possible Lead-Zinc Producers, Ranked in Decreasing Order of Credibility
- Draft 1/23/78 by JHC "Copper Deposits with Production Potential of 75,000 TPY or more"
- C.F. Barber's talk to Copper Club 2/7/78 "On the Economics of New Supplies of Copper"
- Tables on "Proven Copper Reserves in Arizona"

Correspondence Misc.
- 2 Letters from Gill Montgomery May 1982 re consulting work

Costs - Smelting
- Treatment Cost 1-17-79 AJK

Cyanide
- Memo from TD Henderson 2/14/74 "Destruction of Cyanide in Plant Effluents

Desert Varnish
- News Notes - California Geology - March 1978

Desert Survival
- Article

Diamonds
- Article
- Note April 1978 by JHC "Diamonds"

Discovery Rates - U.S.A.
- Article - Jan. 1977

Drill Core Sizes
- Notes

Drill Equip.
- Articles
- Memo to JHC from JR Wojcik 4/2/65 "Summary-Waterloo Hammerdrilling"
- Memo to FTG from SR Davis 7/14/78 "Cost Summary 1977-78 Assessment Drilling-Hardshell Project"
- Ltr. to N. Whaley from Venture Drilling Co. 3/3/78
- Memo to JHC from SE Zelenkov 3/13/68 "Drilling Problem in Australia"
- Ltr to FTG from WLK 2/1/77 - "Dyna-Drill"
- Memo for Steve Von Fay from JHC 2/3/75 "Summitville, Colorado, Drilling and Sampling"

Drill Contracts
- Request for Bid Form - Mission Unit Diamond Core Drilling
- Contract between ASARCO-MEX & Boyles Bros (unsigned)
- Supplemental Agreement 3/20/64 between Boyles Bros & Asarco
- Memo to AF Goldsworthy from AK Guard (JHC date stamp 6/5/69) re: Silver Bell Job No. 6-225 and Michiquillay Job No. 61-1
- Ltr to RF Durfee, Boyles Bros, from CP Pollock 2/21/63 re Michiquillay drill prog
- Whatley Drilling Co. PO T-6565, 6/1/67
- Memo to JHC from Charles W. Haynes (no date) "The Use of Drilling Mud and Additives at Silver Bell"

Drill Logs
- Memo to WLK from FTG 1/3/73 "Use of a Form for Quantitative Geologic Logging"
- Forms - Drill Log.

Drilling Methods - (red folder) Attachment B
- Ingersoll-Rand brochure
- Photos
- Report to AE Ring from JHC 2/3/49 "Churn Drilling and Sampling, Silver Bell, Arizona"
- Memo to RLB from JHC 11/11/77 "Santa Maria Tin, Sapain"
- Memo FTG to NP Whaley 8/23/77 "Hardshell Project, Santa Cruz Co., AZ, Assessment Drilling 1976-77
- Ltr. to JF Lord from JR Wojcik 8/25/69 "Con Core Drill Test"
- Ltr. to JHC from O.Manchak 11/9/77 of Drilling Services Inc. re: circulation rotary drilling
- Design sketches of Churn Drill & of Dump box & Trough

Electronic Metals
- Articles

Energy
- Articles

Environmental - General
- Articles
- Ltr to BLM from FTG 5/25/76 "Proposal for Management, Middle Gila and Silver Bell Planning Units.
- Ltr to JHC from L. Clark Arnold of Pillar, Lowell & Assoc. re: replacing Mining Law of 1872.

Evaporite Basins - Arizona
- Arizona "Fieldnotes" Dec. 1961, June 1973, March 1980

Exotic Copper
- Memo by JHC 7/30/76 "Exotic Copper Deposits (Literature Search)

Exploration General
- Maps, Articles
- Abstract by Leo J. Miller "Corporations, Ore Discovery and the Geologist" 1975
- Ltr to Bd. of Editors, American Scientist from FTG 9/27/76 re article by Brian J. Skinner "A Second Iron Age Ahead?"

Exploration Records - File 2
- Various memos & tabulations 1983 to 1986

Exploration Record Sheets
- Various memos & tabulations 1978 - 1982

Exploration Meeting Notes - Summary
- Listing of Meetings 1965 - 1980
- Program - Meeting March 11-13, 1971
- December (1971) Meeting Papers 1/24/72 by JHC
- 1973 Program - Asarco Exploration - Knoxville

Exploration Mtg Feb. '80
- Letters & Papers re meeting

Exploration - 1975 Conf.
- Letters & papers re meeting

Exploration Meeting March 1978
- Denver Mtg. Program Sept. 28-29, 1978

Exploration Conference Papers 1975
- Various Papers & Reports

Exploration Conf. Notes 1970-71
- Papers & Notes

Exploration Conf. 1973
- Memos 1972-73 re meeting

Exploration Papers - Dec. 1971 Meeting
- Papers & Memos

Exploration Conference Dec. '71
- Notes

Exploration Conference - Dec. 1968
- Note
- Memo to JJ Colling from JHC 9/26/68

Exploration Office - AZ
- Directory of Exploration Offices in Arizona, Nov. 1984 by MN Greeley, AZ Dept. of Mines & Min. Res.

Field Trip Notes
- Memo from FTG 9/23/77 "Silver City, New Mexico, Field Trip, Oct. 3-6, 1977"
- Notes - 1970 to 1977

Fluidization
- Article "A Fluidization Mechanism for Subsidence of Bedded Tuffs in Diatremes and Related Volcanic Vents"

Geologically Permissive Environments
- Ltr. from FTG 1/11/78 "Permissive Environments"

Geochem
- Memo to JJ Collins from JHC 1/11/71 "Stream Sediment Sampling, Copper-Moly"

Geologic Notes
- Notes

Geologic Papers
- Reprint of Kenyon Richard & JHC paper "Som Cretaceous Tertiary Relationships in Southeastern Arizona and New Mexico" from AZ Geol. Soc. Digest Vol III, March 1960
- Reprint from Mining Engineering Feb. 1958 "Geology of Toquepala, Peru" by Kenyon Richard & JHC.
- Reprint from Porphyry Copper Deposits Southwestern North America - "Structure and Mineralization at Silver Bell, Arizona" by Kenyon Richard & JHC 1966

Geologic Time Table
- Table - Major Stratigraphic & Time Division

Geostatistics
- Articles & Note

Gold - Analyses - Ag
- "Sample Size and Meaningful Gold Analysis" USGS Prof. Paper 625-C
- Ltr to WLK from JC Balla 1/31/83 "Sampling of Gold Deposits"
- Article
- Memo from FTG 1/10/78 "Analytical error during metal exploration"

Gold Leach (Heap) Outcomes
- Notes
- Ltr to WLK from D. Skidmore 2/27/81 "Florida Canyon Nevada Evaluation"
- Memo from JD Sell 6/8/83 "Heap Leaching Gold" w/att ltr by RLB 5/31/83 & memorandum by FTG 5/25/83 "Review of Gold and Silver Heap Leach Operations"
- Metal Price tabulations - 2 - April 6, 1981 and April 20, 1981

Gold File 2
- Articles on Gold
- Memo by JHC 9/11/86 "Gold-Silver, Production-Consumption Trends"
- List of Nevada & other states deposits - dated 9/20/85

Gold
- Articles
- Ltr to WLK from DMS 2/19/81 "The Geology of Stockwork Gold Deposits as Exemplified by the Cinola Orebody"
- Memo for JHG Fuchter from JHC 8/5/76 "Archean Gold-Southern Africa (Literature Search)
- Ltr to S.Von Fay from RLB 8/19/77 "South Dakota Estes Conglomerate:
- Memo to SF Von Fay from JHC 5/22/74 "Pre-Cambrian Gold"
- Tabulation - Gold & Silver Quoted Prices 1939-1956
- Memo to JHC from DE Crowell 10/14/75 "Economic Evaluation of Gold Ore Processes-Article by Bhappu & Lewis"

Gold (Continued from pg. 7)
- Memo by JHC 5/16/69 Analyses of gold in igneous, sedimentary & metamorphic rocks
- Memo to WLK from GJ Stathis 5/2/74 "Comments on Arthur Radtke's talk concerning Genesis & Proposed Model of Disseminated Gold Mineralization of the Carlin Type"
- Memo for J.J. Collins from WLK 9/30/75 "Gold Cyanide Plants"
- Memo to WLK from FTG 10/25/73 "Syngenetic gold deposits"
- Table - "Operating Costs of Gold Plants, Free Milling Ores" date stamped 11/4/75

Gold Placers - Lode Prospects
- File Memo from JHC 11/21/86 "Gold Placers Imperial Co., CA"
- Memo to RLB 8/7/85 from JHC "Fossil Placer Gold, Wyoming - Utah-Arizona.
- Ltr to John Balla from JHC 7/7/86 "Montana Gold Placers, Selected areas of Possible Lode Potential."
- Memo to RLB from JHC 11/7/85 "Kern Co., Gold Placers"
- Memo to RLB from JHC 7/19/85 "New Mexico Gold Placers
- File Memo from JHC 8/22/86 "Lost Gold Mine, Monterey Co., CA"
- File Memo from JHC 12/13/84 "Supergene Gold - A Possible Exploration Lead"
- Memo to RLB from JHC 8/26/85 "Picuris District, Lode Gold Prospect, New Mexico"
- Memo to JHC from RLB 6/5/85 "Nevada Gold Placers"
- Article by Harry V. Warren" Supergene gold crystals at Stirrup Lake, BC"
- Memo to RLB from JHC 5/22/85 "Nevada Gold Placers"
- Memo to WLK from JHC 6/16/86 "So. Nevada Mineral Inventory"

Gold-Precambrian Research
- Memosre Cargo Muchacho Mts. Gold Prospects FTG 9/1/82 & GJS 7/30/82

Hydrothermalist, The
- Article

Index Maps
- Notes & List of Maps April 1976

In Situ Leach - Copper
- Article
- Preprint 70AS-319 "Dissolution of Copper Sulfide Minerals from Fractured Ore Bodies"
- File Memo from JHC 6/7/77 "Copper Leaching, In Situ"

Leaching - In Situ
- Articles
- File Memo by JDS 4/5/77 "In-Place Leaching, Oxymin Oxide, Gila County, Miami, Arizona"
- Ltr to JJ Collins from DE Crowell 2/4/74 "Heap/In Situ Leaching with Sodium Cyanide"
- Ltr to WLK From DE Crowell 8/5/76 "In Situ Leaching"
- File Memo from JHC "Copper Leaching In-Situ, E.I. Dupont de Nemours"
- Article - In Situ Copper Leaching Research at the Emerald Isle Mine
- Memo to FTG from JDS 5/20/77 "In-Place Leaching, Oxy-Min Project - Miami, Gila Co., AZ
- Poston Butte, Dowell-Asarco, Proposed In-Situ Leaching Project, Preliminary Financial Study, Jan. 1973, R.B. Crist
- Note to JDS from GJ Stathis 1976(?) "Zonia Mine, Yavapai Co., AZ"

Investment Guidelines Oct. 74 L.P.E.
- Ltr to MP Barnes from JJ Collins 10/2/74 "Investments"
- " " JJ Colling from LP Entwistle 11/18/74 "Investments"

Jackling Lectures
- Articles

Laterites - Tropical Weathering
- Article "Economic Geology and Tropical Weathering" 1978

Land Status Maps
- ARCO Land Status Maps

ASARCO?

Landsat
- Ltr to Harold James, USGS, from JJ Collins 2/17/66 re Orbital Sensors
- Ltr to JHC from RLB 7/30/76 "Landsat-Geosat"
- Ltr to RLB from JHC 7/19/76 "Landsat"
- Article on "ERTS = 1 Imagery" Nov.'73

Lat. Longitude Locator
- Template

Lead Isotopes
- Memo to JJ Collins from LD James 10/30/74 "Lead Isotopes in Exploration"

Lithium
- Article on Silver Peak, NV Feb 1978
- "Search is on for New Sources of Lithium" March 1977
- Memo from JHC 8/2/76 "Lithium (Literature Search)"

(Files continue in third drawer of file cabinet)
(See "J.H. Courtright File Cabinet - Item 2 on List" page 16.)

J.H. Courtright File Cabinet - Item 2 on List

Top Drawer

Ajo Mine - CU Ariz.
- JHC memo 5/18/79 cc: WLK, FTG

Alligator Ridge
- Abstract - Talk at AIME 12/9/85
- Report - 12/3/82 (no name)

Argus Prospect, Calif.
- Maps
- Notes
- Letter to Fred M. Beck 4/24/78 w/Report by JHC 4/24/78

Tertiary Gold Channels - Calif.
- Map

Bagdad AZ
- Notes, Maps
- Summary of Operations 1951 thru Nov.1955
- Letter - 5/3/78 cc: WLK, JDS, FTG
- Report prepared for AIME Dec. 77 Mtg. by R.J. Bonnis, J.E. Nelson
- Report - Bagdad Mine 12/29/56 by Kenyon Richard & J.H. Courtright

COPY

Battle Mt + gold-silver prospecting
- Copies of magazine articles
- Letter 1/23/76 - Gold-Silver Prosp. by JHC cc: WLK, etc.

Bisoni Nev.
- Letter Jan 7, 1977 to WLK from DE Crowell

Bluebird - AZ
- Letter 5/16/69 by JHC
- Magazine Article 4/69

Candelaria - Nev.
- Magazine Article 6/81

Carlin NV
- Magazine Article 2/86 - "The Dee Gold Mine"
- JHC Notes

Chino, NM
- Field Notes - Continental NM 10/4/77 JHC
- " " - Chino NM 10/4/77 JHC

Chocolate Mts. Calif.
- Letter from Barry Watson 10/22/86 w/his reports of 6/14/68 & 9/7/68
- JHC letter 9/17/68 and report 3/24/47, and J.Gibson Report 3/24/47
- Newspaper article Nov. 12, 1982 w/map & comments

SWED
- Letter FTG to WLK 9/29/80 "Microfiche of files"

Christmas Mine AZ - (empty folder)

Cienega Gap
- Geol. Map 1956-57

Commonwealth Mine
- Memorandum 6/2/75 by JHC cc: WLK

Copper Basin, Calif.
- Memo to WLK from JHC 4/15/81

J.H. Courtright File Cabinet - Item 2 on List

Top Drawer (Continued)

Control - AZ
- Notes

Copper Creek - AZ
- Write-up on Newmont Deposit - stamp dated 1/14/72 - w/photo

Dee Gold Mine NV
- Magazine Article 2/86

Hall Moly (Liberty Mine - Anaconda)
- Note

Escalente Ag
- Magazine Article 9/82

Getchell
- Copy of letter 9/5/75 to John Collins, Asarco, from Lawson P. Entwistle

Hardshell AZ
- Hardshell Metallurgy - Test Work 11/20/79
- Speech -(no name or date)
- Memorandum to D.E. Crowell from A.R. Raihl 7/11/79
- Letter to D.E. Crowell from M.El. Tawil 2/12/80
- Maps & Notes

(Duval) Sierrita - (empty folder)

Emerald Isle - AZ
- 3 Magazine articles
- Note

Helvetia AZ (empty folder)

Hillsboro, NM
- Magazine Articles
- Hillsboro Financial Analysis 4-28-75
- Letter from SAA 2/22/77 cc: WLK, etc.

Jamestown area. gold, Calif.
- Report by P.H. Dohms, R.D. Hoagland cc: W.L. Kurtz Nov. 1984

Jerome
- Magazine articles
- Field Trip info 11/18/77

Lakeshore Arizona
- Report by SAA to JEA MacDonald 8/16/78
- Various articles & maps
- Note dated 1-2-69

McLaughlin - Homestake
- Memo 12/29/83 by JHC
- Report 11/1/81 by MLK
- Magazine article
- Note

Mesquite Con. Goldfield
- Memo 10/27/86 by JHC cc: WLK, JDS, etc.
- Assay TAJ 467
- Magazine article 11/8/85

Miami East
- Letter from J.D. Sell 1/22/80 to FTG
- Sketch section

Mineral Butte (Blackwater)
- Article from USGS Bulletin 1278
- Notes

Mount Shasta
- Abstract 3/1/73

J.H. Courtright File Cabinet - Item 2 on List

Top Drawer (Continued)

Mission Paper
- Mission Mine History - JHC

Mission & San X ore reserve
- Memos
- Maps
- Report - "Some Geologic Features of the Mission Copper Deposit" by Kenyon Richard & J.H. Courtright
- Comparative Report - Life of Property 1961-1975
- " " " " " 1961-1976
- " " " " " 1961-1982

Mission Area
- Maps Geologic/Drilling
- Articles/Photos
- Letters between JHC-K.Richard & Ira B. Joralemon re his book

Morenci
- AIME Conference - PD - 1980
- Field Notes

Oldberg Project
- Notes 2-6-75
- Blackwater Mining District Map

Ortiz Grant Au
- Memo 11/7/80 JHC cc: WLK, RLB

Paradise Peak - Au Ag Hg, Nye Co., Nevada
- F.R. Koutz memo (not date - 1986) to J.D. Sell

Picacho Basin Drill Hole
- Field Notes - from the AZ Bureau of Mines June 1973, v.3 no.2

Pima
- Pima Pit Factsheet (article from publication)

Pinos Altos NM
- Pay Dirt May 79 article, & notes by JHC

Pine Grove - Utah
- "Pine Grove-Moly"memo 12/19/79 by JHC
- "Pine Grove Assoc." memo 9/18/79 by J.D. Sell
- Notes JHC

Pinson Gold Nev.
- Magazine Article July 1981

Pinto Valley Copper AZ
- Mine Statistics & Meeting Info 5/19/78

Poston Butte
- Meeting with Continental Oil - 6/23/75 letter from TES
- Cut-Off Comparison 6/18/75

Ray, AZ
- "Structural Geology of the Ray Mine Recent Developments" by S.A. Hoelscher April 16, 1977
- "Geology & Mineralization of the Ray Silicate Orebody" by Neil A. Gambell April 16, 1977
- "Review of the Ray Orebody" by Neil A. Gambell 4/16/77
- "Igneous Rocks and Copper Mineralization in the Ray Porphyry Copper District, Arizona" by Henry R. Cornwall & Norman G. Banks USGS OFR 77-255 1977
- "Mine Planning at the Ray Mine" by W.J. Belobraidich 4/21/79
- "Large Mining Equipment at the Ray Mine" by S.F.Johnson 4/21/79
- "Water Pollution Control at the Ray Mine" by Neil A. Gambell 4/21/79
- Kennecott Copper Corp. brochure

J.H. Courtright File Cabinet - Item 2 on List

Top Drawer (Continued)

Rochester Nev.
- Magazine article
- Notes by JHC

Red Mountain - Patagonia AZ
- Notes by JHC

Rosemont, AZ
- Letter by JDS 3/25/83 "Rosemont Deposit"

Round Mt. - Nev.
- Report by Kenyon Richard 9/30/44 with map

Safford - Ariz.
- Phelps Dodge brochure
- AIME Meeting Dec. 4-5, 1977 info
- Memo by J.D. Sell "Sol Property" 10/7/76

San Manuel - Kalamazoo
- Letter to L.A. Heindl, Nat'l Acad. of Sciences, April 4, 1967, from JHC
- Paper by Maurice Chaffee (1975) "The Zonal Distribution of Selected Elements Above the Kalamazoo Porphyry Copper Deposit, San Manuel Dist., Pinal Co., AZ
- Abstract

Sacaton (2 folders)
- "History and Geology of the Sacaton Mine" by RBC (?) date stamped 1/28/74
- Sacaton Unit, East Ore Body Report 9/14/76 by SAA
- Maps
- "Sacaton Basement Fault" memo 1/27/64 J.E. Kinnison
- "Sacaton Ore Reserve" memo 1/18/69 by JHC & W.E. Saegart
- "Sacaton Ore Reserve and Outcome Estimate Cap. Cost Summary" by J.R. Wojcik 5/28/64
- Memo 9/27/68 by R.J. Wojcik
- "Drilling Recommendations" 9/15/61 by Kenyon Richard
- "Sacaton Mine, History of Discovery" Report by Kenyon Richard 1983
- "Sacaton West Orebody" 5/28/70 report by T. DallaVista
- 5/30/74 memo by JHC
- Magazine articles
- Report "Sacaton Estimate" by C.E. Williams 2/10/72

Santa Cruz
- "Santa Cruz History" by HG Kreis
- Parks-Salyer Area - memos by HGKreis 12/16/81, 1/12/83 & 7/20/83
- Maps & notes
- Letter to FTG 4/18/79 from JHC
- Sacaton - Santa Cruz Prospects" from John Kinnison 5/14/64

Salton Sea
- "Hot Brines of the Salton Sea Basin" by JHC Dec. 1971
- "Hydrothermal Brines" by JHC March 3, 1967
- Article "The Salton-Mexicali Geothermal Province" July 1967 by James B. Koenig

Shasta Project
- " Shasta Project" memo 7/21/72 by JHC
- Map

Silverbell - Mill Site Claims
- "Asarco Millsite Claims" 10/2/81 to BLM from JHC
- Logs/Maps
- Report by Kenyon Richard 10/5/81 "S.B. Mill Claims"

J.H. Courtright File Cabinet - Item 2 on List

Top Drawer (Continued)

Silver Bell (2 folders)
- "Exploration Possibilities Around the Oxide & El Tiro Mineralized Centers, Silver Bell District" to B.K. Malone from David Sawyer 5/18/84
- "History of Exploration at Silver Bell, Arizona" by Fred Graybeal telex 7/1/8
- Article "Sacaton - Asarco's new copper mine in Arizona" from Mining Magazine - Feb. 1975
- "Regional Structural Control of Mineralization at Silver Bell" from FTG to JDS 7/27/83
- "Comparison of Silver Bell, AZ" memo by JDS 7/13/83
- Maps and Notes
- Road Log 1969 AGS Trip
- Reprints from Geology of the Porphyry Copper Deposits 1966
  - " Structure and Mineralization at Silver Bell, Arizona" by Kenyon Richard and James H. Courtright
  - "The Mission Copper Deposit, Arizona" by John E. Kinnison
- Maps
- "Silver Bell, Arizona - Porphyry Copper Mineralization " Report by JHC to F.V. Richard April 7, 1949
- "Arizona Pima Co. Silver Bell Oxide Exploration" to A.E.Ring from JHC 7/17/48

Slumberering Hills - Gold Nevada
- Article from Precious Metals 2/18/85

Superior East
- Map
- Letter to FTG From J.D. Sell 8/27/76

Trench Area
- "Review & Comparison to Trench" memo FRK to JDS 9/18/82
- "TCH-2" memo to FTG from JHC 10/9/81
- Various memos & reports by FRK 1981
- Maps
- Geologic Log
- Notes
- Report by FTG 7/7/80 "Summary of TM-13"

Twin Buttes
- article

Tyrone NM
- Notes JHC

Van Dyke
- Articles
- Occidental Miami East Memo by WLK 9/21/73
- "In-Place Leaching" memo by JDS 5/20/77

Vekol Hills Proj 5/78

Waterloo Calif.
- Report on "Waterloo Ore Reserve" 12/1/66 by R. Kirkpatrick
- "Waterloo Project Reevaluation" memo to TES from Robert J. Previdi 2/17/78
- Article "Geologic Guidebook to the Southwest Mojave Desert Region, Calif. (1976)
- Petrographic Examination of Waterloo Silver Ore by Newmont 10/21/68

Yellow Aster
- Memo from FTG 11/6/79
- Memo from B.J. Devere 2/21/80
- Map

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer

Canada - Publications
- Various publications on Canada
- Report "Univ. of Arizona, Economic Geology Field Trip to Quebec-Ontario, May 14-23, 1973" from F.T. Graybeal 5/31/73
- Memo to W.L.Kurtz from F.T. Graybeal 3/5/74 "Syngenetic Gold Deposits
- Gibraltar Mines - 1st Qtr including June 30, 1972 - Production info
- File memo 8/20/65 from Kenyon Richard "Grand Duke Ore Reserve"
- "A Carlin Type Gold Deposit, Queen Charlotte Islands, British Columbia" by G.G. Richards (no date)

Canadian - Metal Deposits
- Magazine article

Canada - Eastern
- Kidd Creek Mine" by Geological Staff Ecstall Mining Ltd., date stamp 4/2/74
- Various memos re Petrochemistry 1975-1976
- Report to RLB from R.S. Gray 10/15/75 "Quebec, Clericy Twp., Viau Property"
- Notes, Articles, Maps

Canada - Western
- Letter to R.E. Gale from F.T. Graybeal 12/17/81 "Sample Data Forms."
- Article "Lornex Mining Corporation Ltd" 8/72
- Letter from SAA To JHC "Copper Outlook for North America" 9/5/72
- Various memos, notes, maps and articles

Afton Mines
- Report date stamped 5/5/78

Anvil Mine Yukon
- Letter from SAA to JHC 8/26/74 "Yukon Territory Anvil Mining Corp., Faro Deposit 105 K/6" (Report R.S. Gray att.)
- Letter from JHC to J.J. Collings 8/12/74 "Anvil Mine Faro, Yukon" 8/12/74

Black Lake Asbestos
- Letter from JHC to J.J. Collins 9/15/71 "Lake Asbestos, Ltd., Quebec, Canada"
- Note

Equity - Sam Goosly
- Schematic
- Notes

Hemlo Gold - Ontario
- Letter to Staff from JDS "Hemlo Gold" with Field Trip Guidebook to Hemlo Area attached.
- Various articles on Hemlo

Buchans, Newfoundland
- Letter to RLB from JHC "Buchans, N.F. " 7/11/83 w/draft "History of Exploration at Buchans, Newfoundland"
- Maps
- Buchans Mine Report Feb. 1975
- Article "Geology of the Buchans Orebodies" by E.A. Swanson & R.L. Brown, April 1962
- Memo Oct. 11, 1972 to J.J. Colling from JHC "Buchans Newfoundland"
- Letter to L.D. James from RLB 11/23/72 "Newfoundland Buchans Unit Geochemistry" w/memo from L.D.James 11/14/72 attached.
- Maps

Minto - Yukon
- Memo to J.J. Collins from JHC (no date) "Minto Project" w/ltr from SAA to JHC 8/8/72 attached
- Notes
- Memo to N.Visnes 6/19/74 "Minto Pit design and Lifetime Mining Schedule" from C.E. Williams

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer

Sullivan BC
- Sullivan Mine - Map & Text

Sulphurets Creek, BC
- Memo to TCO from JHC 6/7/76 "Sulphurets Creek Prospect"
- Memo to TCO from RE Gale 5/7/76 "British Columbia, Unuk River Area 104/B Sulphurets Creek Cu-Au Prospect"

Stikine Copper
- Memo to JJ Colling from JHC "Stikine Copper and Scud Venture Galore CR. B.C." dated 8/4/74
- Note and Article

Timmins Area - Canada
- Magazine article "On the Relationship between Gold Mineralization and Ultramafic Volcanic Rocks In the Timmins Area, Northeastern Ontario" Sept. 1976, CIM Bulletin

Wisconsin - Massive Sulphides
- Ltr. from JC Balla to WLK "Volcanogenic Sulfide Exploration, Northern Wisconsin - Northern Michigan" dated 11/24/76 w/memo of T.A.Henricksen attached dated 11/16/76.

Central Kentucky
- Ltr. to Deane F. Kent 3/20/67 "Central Kentucky Mineral District Report and Recommendations" from DD Harper

East Tennessee
- Report: Mineral Resources of the American Zinc Company, Appraisal by Expl. Dept. of Asarco, Dec. 14, 1970 w/atts.
- Maps

Eastern Div. USA
- Various Memos, Notes, Maps
- Article UMR Journal No. 1 (April 1968) "Tectonic History of Midcontinental United States" by Frank G. Snyder

SE Missouri
- Article and maps

Rocky Mountain Div.
- Memo to JJ Collins from JHC 8/12/69 "Hahn's Peak, Routt Co., Colorado"
- Memo from RLB 11/16/77 info from Kennecott Prospectus
- Memo to JJ Collins from JHC 9/22/70 "Parkview Mt. Project, Grand-Jackson Cos., Colo."

Buffalo Boy - Silverton Colo.
- Letter to WLK from Stephen Von Fay 9/15/76
- Report to S.Von Fay from C.E. Beverly "Stone Silver Corp Properties, Buffalo Boy Mine ..." 9/13/76 w/map

Climax Colo.
- Notes and Articles

Creede - Colo.
- Memo to TCO from JHC 7/31/80 "Chevron Creede Proj."
- Maps, Articles, Notes

Henderson Colo.
- Memo "Tour-Henderson Molybdenite Mine" date 1/12/72 by John R. King

Homestake
- Articles
- Letter to JJ Collins from Stephen Von Fay 12/3/74 "Gold in the Black Hills USGS Circular 699"
- Letter to S.Von Fay from C.K. Moss "Gold, Black Hills, South Dakota" 1/9/75
- Operating Cost Summary July 1972 of Homestake Mining - Lead Div.

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer

Keystone Moly - Colo.
- Maps, Notes, Articles, Rpt. to Shareholders Crest Butte Silver Mining

Kirwin Wy
- Letter to WLK from D.J. Krasowski 1/31/79 "Kirwin, Wyoming, Amax Copper Deposit" w/Stephen Von Fay memo of 9/12/75 att.
- Article - 1971 Guidebook
- Note

Leadville, Colo.
- Memo to RLB from D.M. Smith "The Black Cloud Story" w/atts. 7/15/83
- Letter "Black Cloud Mine, Leadville Col." 4/12/83 to D.M.Smith from JHC
- Letter "RES-Asarco Joint Venture" - To T.A. Snedden from R.J. Kupsch 4/28/67
- Letter "Re Exploration leading to ore discoveries Black Cloud Area Leadville" from Hal Norman to D.M. Smith 3/21/83
- Various company letters 1978

Copy for Asarco file

- Report:"Resurrection Asarco Joint Venture, Leadville District, Colorado" June 2, 1964 by JHC & R.K. Kirkpatrick
- Appendix A to above Report (separate binder)

Middle Mountain Moly
-"Middle Mountain Moly Prospect" memo from JHC to FTG 9/3/80
- Letter from D.M. Smith to W.L. Kurtz 10/15/80 "Middle Mountain,Eagle Co., CO"

Parkview Mt. Colo.
- Memo to J.J. Collins from JHC 9/22/70 "Parkview Mt. Project Grand-Jackson Cos., Colo.
- Memo to TCO from JHC 5/2/79 "Parkview Mt. Project Grand-Jackson Cos., Colo.
- Memo to JHC from TCO 5/9/79 "Colorado Parkview Mountain"

Red Mt. - Genesse "Tunnel"
- Letter to WLK from JHC "Red Mt. District, Colorado" 11/6/77
- Letter to Charles Alpers, Univ. of Calif. 11/15/83 from JHC w/att.

Summitville Colo.
- Articles, Notes
- Letter to TCO from JHC and WLK 1/9/76 "Summitville Project Colorado"
- Various letters in 1976 to/from S.Von Fay (Asarco RMED)

Eureka Dist. Nev.
- Letter to WLK from FTG "Greater Eureka District" 5/10/79
- Letter to JDS from FTG "Eureka District" 4/18/79

Jerrett Canyon FMC
- Handwritten notes

Escalante Ranches Utah
- Operating costs

Alaska
- Letter "Qtz Hill Molybdenum, Alaska" 3/29/79 to WLK from JCB
- Article on Alaska
- Memo to J.J. Collins from JHC "Boundry Project Alaska" 9/13/71
- Tok Prospect, Southeast Alaska" memo to J.J. Collins from JHC

ARGO Gold
- Articles, 1979 Annual Rpt., Photos 1980

Butte, Montana
- Article

Coeur d'Alene - Idaho
- Articles, Maps
- Copies of Geological Rpts. 1983, 1984 & 1985 from SAA
- Notes

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer

Gold in Algal Reefs - SW Mont.
- Letter "Gold in Algal Reefs" to J.C. Balla from JHC 2/25/86

DeLamar - Florida Mountain - Idaho
- Letter to WLK from J.R.King 6/7/76 "DeLamar - Florida Mt."
- Notes and articles

Heddleston - Montana
- Letter to TCO from JHC 5/14/80 "Heddleston District, Montana"
- Letter to J.J. Collins from JHC 2/18/72 "Anaconda's Heddleston Property Lewis & Clark Cos. Montana"

Little Boulder Cr.
- Notes

Lost River - Alaska
- "Feasibility Report for Lost River Mining Corp. Ltd. on the Lost River Fluorite-Tin-Tungsten Project" Volume 1 - Summary 8/31/73

Montana
- Various letters on "Big Ben Molybdenum Area Montana"1957-1958
- Letter "Climax Molybdenum, Climax, Colorado" 1957

NW Div.
- Notes, Articles
- Memo to J.J. Collins from JHC "Thorn Springs Creek Property, Washington County, Idaho" 7/12/71
- Memo to J.J. Collins from JHC 7/9/74 "Washington, Okanogan County, Mazama (Leslie Den)"

Quartz Hill - Alaska
- Memo JHC dated 1/28/81

Stillwater Complex - Mont.
- Article on Platinum

Thompson G. Moly
- Article - Notes
- Letter to TCO "Cyprus Exploration Co." 10/7/75 from WLK

San Poil - Wash.
- Articles - Notes
- Letter to JCB from TCO "Washington San Poil Prospect" 1/31/78

Spar Lake
- Letter to JHC from JCB 4/18/73 "Spar Lake Deposit, Montana" w/att. 2/16/73 ltr.
- Letter to Keith Whiting from JCB 12/8/72 "Spar Lake Deposit"

Tobacco Root Mts. - Montana
- Maps

Troy Montana
- Articles, Maps, Asarco News Release

Almaden Mercury Mine
- Letter to C.M. Shegley 11/3/66 from G.G.Snow, Dow Chemical "Visit to Almaden, Spain Mercury Mine"

British Isles Ore Controls
- Article "Basement controls on mineralization in the British Isles" 1976

Recsk, Hungary
- Article

Ireland
- Memos from JHC to J.J. Collins 11/2/71 "Base Metal Projects Ireland"
- Memo from JHC to TCO 5/21/76 "Longford Area Island"

North Wales - Por. Copper
- Article "Copper Mineralization in the forest of Coed-y-Brenin, North Wales

Poland
- Articles on Copper

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer (Continued)

Spain
- Ltr. to J.J. Collins from JHC 11/19/71 "Iberian Pyrite Belt, Spain & Portugal"
- Memo JHC 2/16/77 "Raya Tin Project, Spain"
- Articles
- Ltr. to J.J.Collins from JHC 11/18/71 "Mazzaron Project, Murcia Prov., Spain"
- Ltr to R.B.Sprague re Proposed drilling (Mazzarron) 12/15/72 from Joy Merz w/ltr attached from R.B.Sprague to TCO 12/28/72

Santa Maria, Spain Drilling, etc.
- Report on Santa Maria Tin Caceres Spain" to R.B. Sprague from JHC 3/5/79
- Articles, Drilling Info - Maps
- Ltr. to RB Sprague from JHC 12/11/78 "Spain Santa Maria Tin"
- Memo to TCO from M.P. Barnes, M.Barnes & Assoc. 11/20/78 re Santa Maria Tin
- Ltr to R.B. Sprague 11/14/78 from TCO
- Various memos and assay info
- Ltr. to RLB from JHC 6/9/78 "Santa Maria Tin Spain"
- Articles & Notes

Check Assays - S.M.
- Assay Info

Argentina
- Nevados Del Famatina (La Mexicana) ERA w/att.
- Ltr from FTG 2/22/82, TCO 8/13/79, & Rept from Luis Montoya 7/18/79
- Magazine Articles

Mexico
- 1985 Paper by Jesus Gutierrez "Real de Angeles"
- Rpt - Geology of the El Arco Porphyry Copper Deposit (no name)
- Sulfide Zoning in the Breccia Pipes at Cananea, Mexico by Steven Ensign Bushne
- File Memo from JHC 5/8/81 "Cananea, Sonora, Mexico"
- American Institute of Mining Engineers Arizona Conference. Cananea - 198a
- Magazine Articles, Maps, Notes

Field Notes - Mexico
- Trip Notes to Sr. L.C. Woodul 9/2/68

La Caridad - Mexico
- Magazine Articles - Notes

Boleo Copper - Mexico
- Sedimentary Copper Deposits of the Western States by J.W.Finch
- Magazine Article

Chile
- Magazine Articles, Maps, Notes
- Ltr to WLK from FRK 1/25/83 - Mantos Blancos Copper Deposit, Chile(C.N.Alpers)
- Ltr to RLB from FTG 3/6/81 - Current Exploration Activity in Chile
- Report by Fred W. Warnaars 11/25/80 "Copper and Tourmaline Breccias in Los Bronces, Chile"
- Memo to J.J. Collins from JHC 8/26/75 "El Arco, Baja, California" w/att memo of J.R.King 6/11/75.

El Indio
- Report "The El Indio Gold, Silver, Copper Deposit Region of Coquimbo Chile" by Thomas N. Walthier, Ernesto Sirvas, & Ramon Araneda G. (date stamp 1/22/85)

Por.Cop.Leached Cap - Atacama Desert
- Memo from JHC 5/3/84 "Porphyry Copper Leached Cappings in Atacama Desert,Chile

Escondida
- "History and Discovery of the Escondida Copper Orebody, Chile" by Robert O. Wheaton, et al
- Magazine articles
- Ltr. to JDS from FRK "C.N.Alpers - Note #2, Escondida, Chile" 10/20/82
- Ltr to JDS from FRK "C.N. Alpers, Escondida, Chile"9/21/82
- Leached Capping Data & Notes.

Copy for Spare Files

J.H. Courtright File Cabinet - Item 2 on List

Second Drawer (Continued)

copy as Alco file

Escondida Report
- Summary Rpt. 2/13/80 to J.David Lowell from JHC "Escondida Prospect, Chile"
- Notes on Leached Capping & Data

Escondida Maps

Quebrada Blanca
- File Memo from JHC 2/8/82 "Leached Capping Quebrada Blanca, Chile" with paper authored by John P. Hund and James A. Bratt presented at AIME Mtg. 2/22-26/81

Los Bronces - Chile
- Article from March 1986 "Mining Engineering" Exploration and geologic evaluation of the Los Bronces copper-molybdenum deposit, Chile by L.R. Stoiser

Rio Blanco Mine - Chile
- Ltr to TCO from D.P. Cadwell 6/15/76 "Rio Blanco Mine, Cia. Minera Andina, Los Andes, Chile"

Bolivia Tin
- Map

Brazil
- Artilce Oct 1985 "Mining Magazine" "Gold in Brazil" by E.A. Schiller

Central America
- Notes & Magazine Articles
- Report - "Central America Mining Scene" by Enrique Levy, March 1977
- Letter to WLK from G.W.Pickard 7/7/77 "Update -- Cerro Colorado Project... June 29, 1977"

Cerro Colorado - Panama
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- Report by JE Denyer 10/3/77 "Santa Maria, Meeting at Adelaide House, London 27 Sept. 1977"
- File Memo by JHC 3/10/77 "Drilling-Percussion, Foaming and De-Foaming Agents"
- Memo to RB Sprague from JHC 11/18/76 "Rosal Project, Spain"
- File Memo by JHC 2/16/77 "Raya Tin Prospect, Spain"
- Memo to RB Sprague from JHC 12/22/76 "Raya Project, Rosal Basin, Spain"
- "Notes on Bolivian Tin" by JHC 8/12/77
- Santa Maria Tin - Spain" JE DEnyer 6/15/77

Thorium
- Dept. of Interior - news release

Trade Journals
- E/MJ articles

Travel Insurance
- Company letters on Travel Insurance 1975 & 1977

Trucks
- Article

Tungsten
- Tungsten Survey October '77 by JHC
- Articles, Notes
- Memo to TCO from JHC 11/16/77 "Tungsten Survey"
- Mineral Investigations Resource Map MR-25

Uranium
- Articles, notes, news release, maps
- File Memo by JHC 6/17/77 "New Developments in Uranium Exploration in Metamorphic & Intrusive Environments"
- Memo to S. Von Fay "A Review of the Uranium Industry and Recommendations" Oct. 21, 1976
- Memo to Regional Supervisors in US - from L.D. James 11/29/75 "U.S. Uranium, Hydrogeochemical Survey"
- Ltr to WLK from WG Hoskins 12/15/75 re radiometric survey
- Memo to S.Anzalone from WG Hoskins 5/13/68 "Uraniferous Basins of Wyoming compared to the Tertiary Basin in Mohave, Yuma & Yavapai Counties, Arizona
- Ltr to JV Desvaux from WG Hoskins 6/7/76 on Rio Hondo Property
- Ltr to TCO from Stephen Von Fay 10/21/76 "Energy, Uranium review & recommendations'
- Ltr to WG Hoskins from RLB 9/28/76 "Grand Junction Meeting"

Vail Meeting
- Ltr to S. Anzalone from Stephen Von Fay 9/1/76 "Vail Meeting Memorandum, Day Mines Memorandum"
- Memo to Steve Von Fay from Greg Arehart "Day Mines' Leadville Operation" 8/26/76

THIRD DRAWER (Continued)

Visitors - Tours
- Ltrs. & itineraries on various tours 1971-1975

Water Jet Cuts Rock

Weights - Measures

Welded Tuffs
- Report "Welded Tuffs"
- Notes & Articles

Zinc
- Wall St. Journal Article 4/13/77

FOURTH DRAWER (Bottom Drawer)

Three-ring Binder "New U.S.A. Metal Production Forecast - 1985 - From Undeveloped Deposits" JHC 2-9-79 WLK

Folder "Exploration Note File - Reconnaissance" note on folder "Already copies in files these are JHC copies"

Maps 2 - on Cuajone 1977

Various letters, memos and maps on "Nuggetty Gully" Australia 1979

New York, N.Y., January 21, 1987

MEMORANDUM FOR Mr. T. C. Osborne

Attached hereto is a letter from Jim Sell, in which Jim, acting in his capacity as a member of the Advisory Council of the Arizona Geology Society, solicits a contribution from Asarco to the "J. H. Courtright Memorial Fund". The AGS proposes to use income from the fund to support the cost of research, presumably student research, in field work connected with the study of mineral deposits.

The society also proposes to memorialize Harold with a new volume, now planned to be produced on the same scale and in the same quality as the Porphyry Copper Volume, which would concentrate its subject matter on areas in districts where Harold did most of his field work. Some of our people might respond to the call for papers for this volume when it is issued, but I now know of no one who is planning to contribute to it.

Of course, my recommendation is that Asarco contribute to the fund at the scale recommended by Jim Sell. That is to say, I recommend that Asarco contribute $5,000 outright * and agree to match any other contributions made to the fund up to a total of $5,000.

The Arizona Geological Society is a pretty solid organization, it is well managed, and has been in existence nearly 30 years. I believe it is financially responsible, and this responsibility is evidenced by the quality of their field trip manuals and their various publications. Perhaps Asarco might wish to convey its contribution to the fund with some sort of deed or trust, which would stipulate that if the society should go out of existence or if it should fail to use the funds for the purpose designated, the funds would be returned to Asarco. Of course, I am prepared to assemble any presentation necessary for the proper Asarco committee in order to support this recommendation.

R. L. Brown

RLB:mr
Att.

cc: J. D. Sell

* telephone RLB, 2/24/87. $5,000 agreed upon by R & J Osborne and will be approved Wed. March 4, 1987 by Advisory Committee. Check to be sent soon after. No matching funds at this time.

ASARCO

J. H. C.

DEC 1 - 1977

PERSONAL/CONFIDENTIAL

Exploration Department
T. C. Osborne
Director of Exploration

November 28, 1977

Mr. S. Von Fay
ASARCO Incorporated
Denver Office

Dear Steve:

Harold Courtright will be retiring as Chief Geologist at the end of December, and as you probably know we do not intend to appoint anyone in his place. Since 1970, the post of Chief Geologist has essentially been a staff job without any line responsibility; this left Harold free to undertake geological research (e.g. literature search, geological commodity studies, statistical studies, etc.) in addition to acting as senior geological advisor to management. After retirement, Harold will be kept on a modest consulting retainer but will confine his activities to continuing to provide all of us with geological advice.

To make up for the gap in our general geological research capability caused by Harold's departure, we are going to create a new position, Senior Research Geologist, and we want you to take it on, effective January 1.

As Senior Research Geologist, your principal duty would be to undertake wide ranging office geological research cutting across regional boundaries. Some travel would of course be required to visit mineral districts, etc., but you would be more concerned with generating new ideas than with existing projects. We would hope that you could generate many of your own assignments, and you would also carry out assignments suggested from time to time by Mr. Brown and myself. You would report directly to me with copies of all correspondence going to the appropriate regional supervisor (and to Mr. Kurtz for western U.S.). As a start I suggest you:

Expl Record sheet.

1. Assume responsibility for keeping the note files previously kept by Harold Courtright, and screen information re literature items of interest which will now go to you via the record sheets previously sent to Harold. Items of interest (not everything) can be disseminated to other offices where they might be used.

2. Follow-up the tungsten study started by Harold Courtright, with particular emphasis on B.C., the Yukon, and the northwestern U.S.

AMERICAN SMELTING AND REFINING COMPANY
MINING DEPARTMENT
SALT LAKE CITY 1, UTAH

August 17, 1945

Mr. J. H. Courtright
Consolidated Coppermines Corporation
Kimberly, Nevada

Dear Sir:

In reply to your letter of August 14 relative to the position of assistant geologist in our exploration department.

According to your experience record and the recommendation of Ken Richard, you seem qualified for the position but at the present time I could not pay more than $325.00 a month. If you would consider that salary, please so advise me.

Your employment would be contingent upon Pennebaker's willingness to release you as I must give consideration to that.

Yours very truly

W. R. Landwehr

WRL:ES

W. R. LANDWEHR

J. H. C.

AUG 23 1967

New York, August 21, 1967

CONFIDENTIAL

MEMORANDUM FOR: Mr. C. H. Waldmann

Mr. Kenyon Richard has resigned as Chief Geologist of Asarco. His resignation will become effective December 31, 1967. Needless to say, we are extremely sorry to lose Mr. Richard. He is an exceptionally talented mining geologist and highly qualified academically and from 30 years experience in the nonferrous base metals field for guiding and administering the exploration programs we consider essential for maintaining our mining business.

In order that we might consult with Mr. Richard from time to time in connection with porphyry copper projects, a specialized field in which he is recognized as an authority, we have arranged to keep him on the payroll at full pay for the balance of this year. He will be eligible for the year end bonus, if an extra compensation payment is distributed. Both he and Mrs. Richard will be covered by the Asarco Health Plan to the end of the year and Mr. Richard's Group Life Insurance policy will be kept in force to December 31, 1967. Both the Health Plan and Life Insurance are to be canceled as of that date.

Beginning January 1, 1968, we will pay Mr. Richard at the rate of $13,500 per year, one-half his current salary for two successive years, 1968 and 1969; all salary payments to be terminated December 31, 1969.

I have explained to Mr. Richard that he may withdraw his contributions of approximately $13,370.00 from the Asarco Pension Plan and take a noncontributory vested benefit of about $665.00 per year beginning October 31, 1980, his normal retirement date. It is understood these figures are subject to verification by the Metropolitan Life Insurance Company.

Will you please make the necessary changes covering Mr. Richard's employment in accordance with the above arrangements.

C. P. Pollock

CC-EMcLTittmann
RWVaughan
DHSoutar
HLGoodenough
KRichard

BlindCC-JHCourtright - Personal

ASARCO

JDS

Exploration Department
Southwestern United States Division

James D. Sell
Manager

January 8, 1987

Mr. R. L. Brown
Vice President
ASARCO Incorporated
New York Office

J. H. Courtright
Memorial Fund

Dear Mr. Brown:

A "J. H. Courtright Memorial Fund" Committee has been established to honor James Harold Courtright, retired Chief Geologist of Asarco Exploration, who passed away on December 7, 1986. The fund will be administered by the Arizona Geological Society Advisory Council.

The proceeds of the interest from the fund will be disbursed for aiding in the resolvement of geologic problems by any member of the profession. Applications for this grant will be processed and awarded by the Advisory Council. It is probable that field study results, of which this funding grant may be a part, would be reported verbally at the meetings of the Arizona Geological Society, or submitted for publication in the ongoing AGS Digest series.

Harold was a Charter Member (1948) of the Arizona Geological Society and has contributed to the stability and expansion of the Society through his participation as a member of various committees, his publication of papers in the Digest volumes, his organization of field trips, and in financial backing at various times in the Society's growth. Harold was President of AGS in 1968-1969.

An announcement of the establishment of the JHC Memorial Fund (attachment) has been distributed to the AGS membership, and $700 of contributions have been received as of this date. The AGS Advisory Council has also voted a $1000 matching fund for these contributions to the Memorial Fund. This support exemplifies the high esteem for Harold and for his achievements.

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703
1150 North 7th Avenue (602) 792-3010

Support for the J. H. Courtright Memorial Fund will also be invited from the general geologic profession of individuals and company groups.

I recommend that Asarco contribute a substantial amount to the J. H. Courtright Memorial Fund, say a $5,000 contribution, with an additional $5,000 matching fund incentive on individual contributions. A larger contribution would provide an increased base on which to expand this Memorial to a field-oriented geologist and friend, J. H. Courtright.

This timely donation would be publicized in future solicitation from other individuals and companies. Contributions should be submitted payable to the "Ariz. Geol. Soc. - JHC Memorial Fund," c/o Arizona Geological Society, P.O. Box 40952, Tucson, AZ 85717.

The AGS Publication Committee has also authorized a future volume in their Digest series to honor James Harold Courtright. At present, the format will include deposits, outcrops, and ideas from South America to Casino, Yukon, where Harold also left his footprints, hammer marks and thoughts.

Sincerely,

James D. Sell

JDS:mek
Attachment

cc: J. Harold Courtright Memorial Fund Committee:
James A. Briscoe, Byron S. Hardie, Kenyon E. Richard, James D. Sell, Jan C. Wilt, Will Wilkinson (President, AGS)

ARIZONA GEOLOGICAL SOCIETY
P.O. BOX 40952, UNIVERSITY STATION
TUCSON, ARIZONA 85719

J. Harold Courtright Memorial Fund

To Friends of Harold Courtright:

Our longtime friend and colleague, J. Harold Courtright died Sunday, December 7,8, 1986, in Tucson. Throughout his 45-year career he investigated innumerable mineral deposits and geological problems and was responsible for putting a large number of ore deposits into production. Because of his influence on the geology of the western cordillera and his founding and longtime support of the Arizona Geological Society, a memorial fund is being established through the Arizona Geological Society. The purpose of this fund will be to support studies similar to those done by Harold Courtright.

Building this memorial fund will begin immediately in order to accomodate those who wish to contribute before the end of 1986. Indivual and matching corporate funds will build an endowment so that the yearly interest can be used to fund grants for educational or geological problem solving.

A J. Harold Courtright Memorial Volume is being planned for publication in the Arizona Geological Society Digest series, the proceeds of which will also contribute to the memorial fund. Initial plans for this volume are to include reminiscences and anecdotal contributions concerning Harold's career and short technical papers on mineral deposits or geological problems with which he was involved.

Checks can be made payable to Ariz. Geol. Soc. - JHC Memorial Fund. Please send your contribution to the Arizona Geological Society, P. O. Box 40952, Tucson, AZ 85717.

Sincerely yours,

Will Wilkinson

Will Wilkinson
President, AGS

J. Harold Courtright Memorial Fund Committee
James A. Briscoe, Byron Hardie, Kenyon E. Richard, James D. Sell, Jan C. Wilt

D R A F T

JAMES HAROLD COURTRIGHT

b. April 26, 1908, Yakima, WA
d. Dec. 7, 1986, Tucson, AZ
m. Viola Louis

son James David
son Timothy W.

Education

Sacramento City College, Sacramento, CA

Feb. 1933 - June 1936, BA
Feb. 1937 - June 1937

Univ. of Nevada (Mackay School of Mines), Reno, NV

Sept. 1940 - June 1941

Societies & Memberships

Amer. Inst. Min. Eng. 1941
AZ Geol. Soc. 1948 (Charter Member)
VP 1967-1968
Pres. 1968-1969
AZ State Bd. of Tech Reg. Dec. 3, 1964 #5927
Geol. Soc. Amer. 1954
Mining Club of SW 1971 (Charter Member)
Soc. Econ. Geol. 1952

Employment

Consolidated Coppermines Corp.

Dec. 1941 - Oct. 1945. Geologist; Asst. Ch. Geol., last year Kimberly, NV. Open-pit and UG mine geological work, mine examination, prospect examination, and supervision of exploration. E.N. Pennebaker and K.E. Richard.

ASARCO Incorporated (American Smelting and Refining Company)

Summary:

Oct. 1945 - July 1960.	Geologist
July 1960 - July 1963.	Asst. Chief Geol., SW Expl.Div.
July 1963 - Jan. 1970	Chief Geol., W. USA, Mex., and C. Amer.
Jan. 1970 - Jan. 1978.	Chief Geol., Asarco Expl.
Jan. 1978 - Dec. 1986.	Consult. Geol., Asarco Expl.

D R A F T

Detail

Oct. 1945 - Dec. 1947. Resid. Geol., Kokomo & Leadville Dists., CO, in charge of exploration. W.R. Landwehr.

Dec. 1947 - April 1949. Resid. Geol., Silver Bell Dist., AZ, in charge of exploration. W.R. Landwehr & K.E. Richard.

April 1949 - Jan. 1950. Geol., Toquepala, Peru, geol. mapping and supervision of exploration. H. Kursell & K.E. Richard.

Jan. 1950 - June 1951. Geol., SW Mining Dept., Tucson, AZ, mine and prospect evaluation. W.R. Landwehr and K.E. Richard.

June 1951 - Feb. 1952. Resid. Geol., Nigeria, Africa, in charge of exploration. C.E. Prior.

Feb. 1952 - Sept. 1952. Resid. Geol., Concepcion del Oro, Mexico, in charge of exploration. T.P. Clendenin.

Sept. 1952 - Jan. 1955. Geol., SW Mining Dept., Tucson, AZ, general exploration in western USA. W.R. Landwehr.

Jan. 1955 - Sept. 1955. Geol., Toquepala, Peru, supervision of drilling and sampling. A.C. Hall and K.E. Richard.

Sept. 1955 - June 1957. Geol., SW Mining Dept., Tucson, AZ, general exploration, western USA. K.E. Richard.

June 1957 - Dec. 1957. Geol., SW Mining Dept., Tucson, AZ, evaluation of prospects and mines, supervision of exploration NW USA and British Columbia, Canada. P.I. Conley and K.E. Richard.

Dec. 1957 - July 1960. Geol., SW Mining Dept., Tucson, AZ., general exploration, SW USA. T.A. Snedden & K.E. Richard.

July 1960 - July 1963. Asst. Chief Geol., SW Expl. Div. K.E. Richard.

July 1963 - Jan. 1970. Chief Geol., Western USA, Mexico, and Central America. C.P. Pollock, K.E. Richard, J.J. Collins.

Jan. 1970 - Jan. 1978. Chief Geol., Asarco Exploration, C.P. Pollock (?), J. J. Collins, T.C. Osborne.

Jan. 1978 - Dec. 1986. Consulting Geologist, ASARCO Incorporated. T. C. Osborne, R.L. Brown.

JHC

Harold left his footprints in many places of the World. No ~~exposure in outcrop~~ outcrop was mundane — all had a story to tell. As a geologist a long time ago wrote .... "There are all the rocks to see .... and they speak for themselves" and Harold ~~would~~ might add .... "and now stop, look, and listen".

I hope it is not unusual for people to have ideas pop into their head and it often happens to geologists too. So often, with some intrepidation you would go see Harold the manager and propose to go see this or that. He'd listen to your ~~spec~~ speculation, then tell you a few more things (and if you had read the files you knew that Harold had been there before) and send you on your way.

As you also know, there are many "doggy type" prospects in the exploration field and Harold had looked at his share and here you come along and want to look at it again, ie, the reason you went ~~it~~ in to talk to him. Oh my, it is still a "doggy" prospect and with some deflation you return to Tucson and report in as so. Ah ha, with Harold, you didn't get off the hook — he knew what he had seen — but now he wanted to know

what you had seen and what were the implications!

Observation – Interpretation – a hallmark of Harold.

JHS 12/11/56

JHC

Harolds large shoes and gait was well known by those who ~~paid~~ shared in the field trips with him. Harold was never one not to ask a question or two on the other persons observations at an outcrop and offered his own observations. As known, this often leads to excessive verbage by various members of the geologic group and when th discussion became full circle, and all were going round o round, you'd see Harold slip away o before you could hardly say boo he was off looking at another exposure that might have ~~the~~ another facet o possibly the answer to the storm still ~~being~~ issuing from the previous exposure. A remarkable man is Harold.

JOS 12/11/86

JHC

The paper said that Harold was an Ex-Geologist. Hmm, well I'd say he was an expatriate from the Cascades, tho even so he spent many summers in their shadows; He might have become somewhat exasperated at some of us; but he didn't become excitable nor extreme in his discussions with us. I know Harold was an exemplary geologist and person; I know that he was an exonerate manager in that exploration with its non-success was a dependent factor and needed to be examined and explained but a successful idea, drill hole, geophysical interpretation, and one pending was due to express individuals ~~to be commended~~ and a cover letter of commendation was forthcoming. Yes. Harold was exalting, he excelled, he enjoyed excursions and we thank Harold for his existence and being an explorer and geologist forever in our minds.

JOS. 12/11/86

J. H. C.

JAN 1 1970

AMERICAN SMELTING AND REFINING COMPANY
EXPLORATION DEPARTMENT
120 BROADWAY, NEW YORK, N.Y. 10005

C. P. POLLOCK
VICE PRESIDENT

December 31, 1969

AIR MAIL

Mr. J. H. Courtright
American Smelting and Refining Company
P. O. Box 5795
Tucson, Arizona

Chief Geologist

Dear Mr. Courtright:

Since your duties as Chief Geologist will require that much more time be devoted to Company-wide affairs than in the past, it is advisable to outline, in a general way, your activities for the future.

As Chief Geologist, your principal concern will be to initiate new projects at all Exploration Divisions in the search for new reserves for Asarco. You will advise me as to any opportunities for improvement in the quality of geological work being done at any of the Exploration offices and on the competency of the geological personnel.

You will advise and consult with the Supervisors on the qualifications of prospective, new geologists. This is a matter of experience in judging the ability of these men.

In order that we may have the benefit of your wide experience, you will visit the projects at the various Exploration Divisions at appropriate intervals to advise and consult with the Supervisors on exploration problems.

You are expected to supervise the activities of the Research Geologist, Mr. Stephen VonFay, who is presently engaged in the search for new projects.

Although Tucson will continue to be your home base, you will report to me in New York. You will remain on the Southwest Department salary roll and they will furnish other necessary facilities.

I want to take this opportunity to compliment you on your promotion. It is obvious I have every confidence that you will continue your excellent work.

Sincerely,

C. P. Pollock

CC-LPEntwistle
RJLacy
DMFletcher
JVDesvaux
SAAnzalone
RKKirkpatrick
JFLord
KWhiting
WESaegart
RBSprague
TCOsborne
RLBrown
TASnedden
RBMeen
KvondenSteinen
SVonFay

ASARCO

Exploration Department

November 6, 1975

TO: DIVISION SUPERVISORS

J.J. COLLINS

I presume you have all been advised that John Collins is leaving the Company at the end of this year; however, Mr. Osborne will take over December 1st, as John will depart from New York on that date.

I am sure those of you who know John personally would like to participate in the purchase of a gift as an expression of appreciation. A range of $5.00 to $10.00 per person is suggested. Please understand that this is not a blanket request, but a suggestion. You should pass on this memo, or advise, only those staff members that you are certain would definitely wish to be included in the list of donors.

Since time is short, please send me, by telex or night letter cable, your list of donors and only the total amount pledged. This applies to foreign offices only. Mail within the U.S.A. should reach here in time. Funds can be collected later and sent to this office as we will finance the purchase.

J. H. Courtright

J.H. Courtright

JHC:vh

cc: T.C. Osborne - Personal & Confidential, R.L. Brown, J.V. Desvaux
L.P. Entwistle
J.F. Lord
D.P. Cadwell
J.J. Merz
L. Montoya

Division Supervisors:

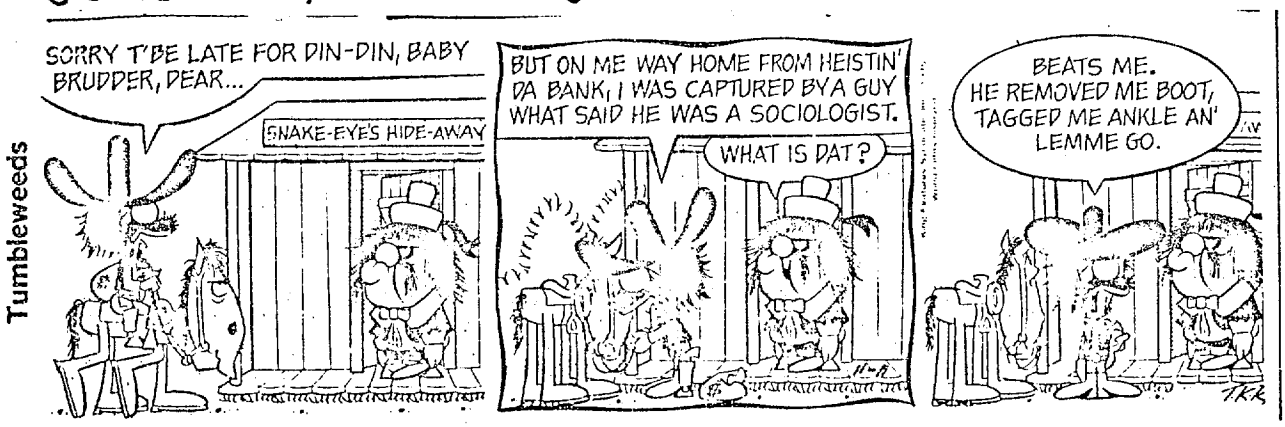
S.A. Anzalone
J.C. Balla, E. Whiting
M.P. Barnes, C.K. Moss, L.D. James
B.J. Devere, Jr.
D.M. Fletcher
J.H.G. Fuchter
R.S. Gray
D.D. Harper
W.L. Kurtz
R.B. Sprague
S. Von Fay, R.K. Kirkpatrick

Tucson, Ariz.
11-17-75

Dear John J.

This is my favorite and only comic strip since Walt Kelly and Pogo departed.

When you told me about your plans several months ago to leave unless the office was moved West, I somehow felt that you would succumb to persuasion



when the time came. But now that its a fact, I want to express my deep appreciation for your more than generous support thru numerous ups and downs.

Many highly capable business men have directed exploration at the top level; however, in my estimation you have the distinction of being one of the very few, possibly the only one, who consistently applied geology, rather than prostituting the profession — an all too common practice — and at the same time successfully coped with the top brass of a large corporation. Your consideration and fairness in dealing with subordinates, individuals, is an equally outstanding and rare characteristic.

I regret that we failed to come up with a "world beater during your term, but guess that can be called "the rub of the green."

We hope to see both you and Bea soon for a few rounds of golf out here in the desert.

Hasta la Vista

J.H.C.

RECEIVED
JAN 5 1975
EXPLORATION DEPT.

New York, December 31, 1975

J. H. C.
JAN 5 1976

MEMORANDUM FOR: Messrs. R. L. Brown, J. V. Desvaux, J. H. Courtright, M. P. Barnes, C. K. Moss, L. D. James, J. R. Wojcik, W. L. Kurtz, F. T. Graybeal, S. Von Fay, D. D. Harper, J. C. Balla, S. A. Anzalone, R. S. Gray, R. B. Sprague, J. J. Merz, L. Montoya, J. H. G. Fuchter, D. P. Cadwell, D. M. Fletcher, B. J. Devere, Jr.

Exploration Department Organization

I believe you are probably all aware of changes which will occur within the Exploration Department upon Mr. Collins' retirement today, and this memorandum is intended simply to place this information on record.

Effective January 1, I will be Director of Exploration and Mr. R. L. Brown will succeed me as Assistant Director of Exploration. Also effective January 1, Mr. W. L. Kurtz is appointed Manager, Western USA, remaining at Tucson. Mr. R. S. Gray will succeed Mr. Brown as manager of the Toronto Office and Mr. F. T. Graybeal will succeed Mr. Kurtz as manager at Tucson.

I will have general responsibility for all programs of the department, and in my absence or unavailability Mr. Brown has authority to act for me.

Detailed reporting by our offices and sub-offices will be divided for convenience between myself, Mr. Brown and Mr. Kurtz. The Vancouver, Perth, Manila, South Africa, and Chile Offices should direct all correspondence to me; the Toronto, Knoxville, and London (Madrid and Ireland) Offices should direct correspondence to Mr. Brown, and the Tucson, Salt Lake Exploration, Denver, and Spokane Offices should direct their correspondence to Mr. Kurtz, with copy to me in New York. (Please note there is no need to send copies to me of correspondence addressed to Mr. Brown, or vice versa, as all material coming to New York will cross both our desks). Messrs. Courtright, Moss, James, Barnes (when acting as Chief Computer Geologist), and Wojcik (when acting as Placer Engineer) will report directly to me on general matters and will continue to address correspondence on specific matters to the individuals concerned, with copy to me. Please note these reporting arrangements are for convenience and I intend to keep in close touch with all of you.

My home telephone is 201-232-7285 and Mr. Brown's is 201-377-0246. It should always be possible for you to reach one of us on matters of urgency, but in the unlikely event that this is not feasible you are free to call Mr. Hennebach directly.

If there are any questions about the above arrangements, please don't hesitate to ask. I trust the transition will take place smoothly and I look forward to continuing our association. With best wishes to all of you for the New Year,

T. C. Osborne

THIRTY-YEAR EVOLUTION OF PORPHYRY COPPER EXPLORATION IN SOUTHWEST USA[1]

PART 1. TECHNIQUES AND PHILOSOPHIES

by

Kenyon Richard[2]

More or less 30 years ago there was a gradual but profound change in mineral exploration —particularly in porphyry copper exploration.

Functioning for the first time in organized, systematized groups outside of their home districts, mining geologists themselves became regional prospectors.

In order to explain that last statement, I feel that I must go back, not just 30 years, but into the last century, even earlier, for a number of comparisons, because the contrast in exploration procedures is distinct; and by no means are the distinctions all due to new technological capabilities.

Through very early Biblical times, and the Cypriots, Romans, and Conquistadores, to name a few, the prospector-miners were slaves. That's low-cost operation at its lowest, particularly because the families of the slaves had to feed them.

The Queen of Sheba is a good example of ingenuity. She operated a lode gold mine. The slaves who rotated her hand ore grinders were blinded. Even if they did find nuggets, they couldn't escape. She certainly needed no time-motion analyst to explain the meaning of operational efficiency. Her biggest headache probably was maintaining a monopoly on the slave market because her labor turn-over must have been high due to early insanity among the workers.

The first "free" prospectors in history were the California '49ers. They were free, that is, to blister in summer, freeze in winter and starve year-round. On average they barely made wages. But they came from all over the world and they didn't return home when the placer gold deposits were soon worked out. Some became ranchers, store owners, blacksmiths, and the like, and most prospered; but some took their California gold pans, spread out over the West, learned to detect other heavy minerals and metals, and taught themselves and their successors a few characteristics of ore deposits. These men became the prospectors, and a very few of them became the discoverers of bonanzas, the real founders of the burgeoning mining business of the West.

However, most of them ruined themselves with hard, useless work because they lacked education—even the rudiments of business, engineering, or geology—partly because it was not available, but mostly because they were too rough-hewn to have bothered with it anyway. Consequently, they tended to regard almost any mineral showing as a probable orebody; they simply did not recognize the tremendous odds against success; they were imbued with the Western tradition of toughness; and they were sustained by that marvelous incentive for human endeavor: the dream of instant wealth. Altogether, the thousands of miles of hand-driven workings on worthless mineral showings is staggering to contemplate.

They found many thousands of mineral deposits. But with the exception of those few bonanzas, the instant wealth didn't materialize.

Most of the prospectors realized rather early they could not convert the discoveries of seemingly fairly good mineral showings into instant wealth either by themselves or in hard-working small groups. To some of the discoverers it became evident that the making of mines required talents and resources they lacked: First, an understanding of geology such that a discovery could be evaluated without blindly undertaking a terrible amount of fruitless hard work; second, an appreciation of mining engineering, management, marketing, etc; and most important, a supply of money and knowledge of its use.

The bonanza discoveries, of course, early attracted money along with engineering and management talent. When the ore was rich, however, the mine operators could and did make many expensive exploration blunders—unnoticed. So, recognition by anyone of a need for knowledge of the geology of mineral deposits evolved very slowly.

The earliest individuals doing "mining"

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[1] Banquet Address

[2] 11 E. Orange Grove Rd., Tucson, Arizona 85704

geological work of a special kind—for example, men like Becker and Hague of the Survey who published classics respectively on the Eureka and Comstock Lode districts of Nevada in 1882 and '83—were only scientific observers and describers, educated in Europe—and they worked only on the known bonanza deposits.

The same can be said for the next generation of geniuses, such as Ransome and Lindgren. They were marvelous scientific observers; they were not discoverers; but they were teachers, inasmuch as their publications and their fame improved and speeded the movement of the knowledge of mineral ore occurrences from European universities to eastern United States and on to the West.

Rather tardily, mining geology became available in the West. The more progressive mining companies began to hire men with education in the science of mineralization. Their exploration judgment gradually began to replace the whims of the mine shifters, the superintendents, the surveyors, the astrologers, and the like.

Anaconda formed the first and justly famous geological department. Other companies, large and medium sized, imitated Anaconda because of its reputed great success in ore finding. These new departments in other companies also found ore. The very important point here is that these departments of mining geology and their increasing knowledge of ore occurrence primarily functioned to find ore in company-owned mines, properties and districts. With the exception of checking out some prospects brought to their attention, no mining geologists really were prospecting for new districts in a regional sense—at least, they were not getting far from home base.

The rapidly improving knowledge about mineralization was still not directly available to to the prospectors. As time went on they still did not understand, themselves, really how to evaluate a newly discovered mineral showing, or for that matter, how to check out an old prospect in light of new economic conditions.

So—a technique evolved which had innumerable variations and ramifications and which I can only crudely describe here.

I term it the "walking through the door" technique. After digging around a bit on a new discovery—or possibly opening up the workings of an old prospect acquired with his second cousin's life savings—the prospector collected a few samples and specimens and went in search of the right office door to walk through. This might be the office of a nearby small mine manager, or the friend of a friend who knew a fellow who . . . , etc., or a lawyer, or a promoter who knew a mining vice president. Briefly, he had to get through a door behind which was the right combination of money and exploration-mining talent. This usually meant a medium-to-large company.

If he walked through that right door, it only meant that his mineral showing would get a proper evaluation, hopefully favorable and with a follow-up. If not, there were other mining company doors. Otherwise, there were doors such as stockbrokers'. In those days money from stock sales seldom involved much in the way of preliminary evaluation of a prospect; blatant misrepresentation was common; but money from valid stock sales did find and develop many orebodies.

The implication is not intended that the men with exploration and mining talent and the money managers were hiding behind their doors doing nothing but wait for bonanzas to walk in. They were quite busy with their own mines. Rather, and this is the whole point, the prospectors and promoters were keeping the mining companies sufficiently supplied with "outside" prospects worth the gambles of exploration and development. As a result the supply of base metals was being augmented enough to keep up with the demands of the growing industrial revolution. The mining geologists not only lacked the time, it wasn't even necessary for them to become real regional prospectors outside of their home mines and districts.

This system worked even though it grew accidentally; it was unorganized and haphazard, and it was unfair to the prospectors. It worked because the successive generations of prospectors had those recurring visions of the rainbow's end. Even if the rudiments of knowledge about mineral occurrences—and their vagaries—had been available to the prospectors of, say, 70 and 100 years ago, they wouldn't have listened because, if I may repeat myself for emphasis, all of those men were motivated by the delusive incentive of instant wealth.

The walking-through-the-door system was still functioning—willy-nilly, but effectively—when I got out of college. And in one form or another it will always be part of the business.

The first organized exploration program in history was undertaken, I believe, when World War II was looming and the U.S. military was shocked (and probably indignant) to learn that God had not provided instant domestic orebodies of quite all the minerals and metals the generals wanted for a new war. No brilliant exploration ideas seem to be immediately at hand, so the government reacted by

legislating instructions to the U.S. Bureau of Mines to find orebodies of seven strategic metals and minerals. For at least two reasons this was a dirty trick on the Bureau: First, they didn't really have good reasons to know where and how to explore for new supplies of these strategic items; and second, being very conscientious mining engineers, they thought they were supposed to know.

The Survey was fitted into some advisory capacity to the side and provided considerable help, so I understand, particularly when another law enhanced the problems by adding six more short-supply items.

A massive bureaucratic effort was made in which there was a great rejuvenation of interest in prospects and properties, practically all of which had already been turned down as too risky by private companies, usually by several, but, mind you, always on the basis of non-wartime economics . . . A new "through the door" procedure developed. It became a mad dash, not a walk, because the exploration money was not only free, it was wrapped in patriotism. Despite this frenetic atmosphere, the basics of the old system still prevailed. The prospector, or mineral property owner, or small-mine owner still had to get the attention of the experts behind the door. This time the door was government. The experts were more concerned with the collection and accuracy of details, but somewhat less concerned with exploration risks.

Despite the Bureau's mandate, which could have invited some pretty wild exploration, prospects and properties were checked thoroughly. Many drilling risks were taken, but only with care and thought. A few tons of ore were found here and there, but only one real discovery—San Manuel—resulted from the entire program, and that was too late to benefit the war effort. B. S. Butler of the University of Arizona and earlier USGS fame, and Nels Peterson, USGS, were the instigators of that discovery.

Considering their sincere efforts, the men conducting that major wartime exploration project deserved more luck. If viewed strictly from a commercial standpoint the program failed. The profit from ore found was small as compared with the program's cost. But, of course, it was not really supposed to be a commercial success. From philosophic and scientific aspects, however, I believe it was successful. It had only a few new geologic concepts for original impetous, but the published results eventually were of great value to future workers.

The big changes in exploration, particularly porphyry copper exploration in the Southwest, took place after World War II. The results of the Bureau and Survey programs had an effect; but the changes were not directly related to the war's end or to dramatic economic changes, or, since Ralph Nader hadn't arrived yet, to any great public outcry that something had to be done about something.

Rather, the realization gradually evolved in the minds of a few that, at least in the case of porphyry copper, it was possible that neither the prospectors nor the earlier geologists had really known how to find any but the rather obvious ore districts. The San Manuel discovery probably had some effect on this line of thought. This meant that (1) some other porphyry copper orebodies could be around somewhere and (2) the mining geologists had to re-do the copper prospecting job themselves.

There were other factors related to the changing copper exploration philosophy, and I'll get to those momentarily. First, though, let me indulge in a bit of narrative because I was involved somewhat myself. If you haven't already, you will note some difficulty in my being objective about a philosophy which is mostly subjective anyway.

E. N. Pennebaker, as consulting geologist for Consolidated Coppermines Corp., originated and conducted the first systematic program of regional prospecting for porphyry copper orebodies in the Southwest. It was begun in '48 and continued until '52 when the company was beginning to fold.

Penny had a staff of four to six young but excellent geologists. Ray Ludden, now manager of western exploration for Phelps Dodge, was one of the group. Their specific objective was to find new porphyry copper alteration zones. They used the state map to spot Laramide intrusives and they combed the Mines Handbook for leads like FeO-cemented gravels and for fringe manganese deposits like Bisbee and Ely. They jeeped and walked all over the place. They found about a dozen porphyry copper deposits not known as such theretofore, although a couple were near known porphyry districts. After finding an alteration zone, they would map in detail with particular attention to leached capping interpretation.

They drilled several holes in each of four, which I'll identify as Safford, Kelvin, Patagonia, and Yerington. I believe they penetrated ore-grade material in all four and they had one drill hole in the middle of what is now Kennecott's big Safford orebody. That's a pretty good record considering that they were constrained with the need for a +1.0% Cu orebody at a 0.6% cutoff. The copper price

didn't jump quite soon enough for them, that's all. They were mining geologists who became the first organized group that didn't wait for a porphyry copper prospect to walk through the office door.

While working at Silver Bell and then in southern Peru in the late '40s on some of those copper deposits, particularly Toquepala, Harold Courtright and I began to realize that green copper-stained outcrops could be seriously misleading in terms of copper sulfide ore occurrence. (By cutting myself in on this, I'm stretching things a bit because, as I suppose some of you know, I'm color blind—green copper stain comes through as a nice clean gray—so, I wasn't mapping the stuff anyway.) I did, however, contribute in various ways. I can assure you there was no great flash of insight involved. In fact, there were many complicated aspects of Toquepala geology: We were busy disagreeing about a lot of these other things, and I don't believe we began to think much about the copper-stain business until later when I had had a chance conversation with Juan Oviedo, the original owner of Toquepala. It then became evident that Cerro de Pasco had almost walked away from Toquepala without testing the sulfide zone. Apparently they thought the copper-stained outcrops were the guide to ore. What I want to emphasize is that, if Cerro had walked away, Southern Peru might today still be a rugged, discouraging desert with 2 or 3 billion tons of untested copper ore.

A steep-walled canyon cut the middle of the Toquepala deposit. A few small patches of weak copper-staining occurred high on the canyon walls in the fringe zones of alteration. Cerro had driven about eight adits, 250 m each, beneath these surface copper showings. They cut no sulfides and their adit assays were sometimes as high as 0.1% Cu. They were prepared to move out their camp. So, in desperation rather than with knowledge, Oviedo sank a shaft in the bottom of the canyon. Within 15 m his shaft encountered disseminated chalcocite averaging 4.0% Cu. Cerro stopped packing and started drilling.

Actually, Harold and I were rather slow to catch on. But we began to discuss the possibility that porphyry copper sulfide ore easily could occur in many other places without the need for directly overlying copper-stained outcrops.

The idea was simple, but a lot of other geologists had not caught on either. I worked with Blanchard for several weeks in '47 and I've talked with Locke and Tunell. I believe they all thought of the technique of leached outcrop interpretation, which they originated, as being useful in finding more ore in already discovered districts. It seems rather incredible, but I don't believe they considered it as being a means of discovering entirely new, separate deposits or districts by re-prospecting large regions. None of their publications state this as a possibility.

Anyway, Courtright and I thought the idea was important enough to warrant re-prospecting the Southwest United States and many other regions.

American Smelting didn't exactly respond with alacrity to my report describing how this prospecting should be done. While working on the Flux mine in the Patagonia Mountains, however, Courtright recognized porphyry copper alteration without copper stain, and I was sent to check it out early in '51.

That's where we ran headlong into our old friend Pennebaker and his crew. We had worked for Penny in the 30s and 40s at Ely, and we knew Ray Ludden and others of his crew. Also, Phil Jenney, representing Coppermines' partner, American Metals, used to show up frequently. We all stayed at the same motel and, as you can imagine, altogether there was quite a bit of socializing while we were stealing secrets from each other.

Of course, it was immediately evident that, although arrived at independently, our basic exploration ideas and Pennebaker's were about the same, only he was three years ahead of us.

Anyway, between Patagonia and the border there were plenty of porphyry copper alteration zones and breccia pipes for everyone. A number of holes were drilled, but there was no significant chalcocite enrichment. We all pulled out. Too bad none of us had the instincts of real estate operators. In terms of one kind of exploration philosophy and how it changed, everyone then was using about 18¢ copper when making projections into the dim, distant future of, say 1960 or '65.

I've dealt with the leached-capping-without-copper-stain idea rather at length because, although a simple geological idea, it had been overlooked. It got some drilling programs started. In turn, that activity got other groups interested. And so on.

Also, though, at about that time important new geophysical, geochemical, and other techniques were appearing and adding significantly to the changes in exploration. A change more important than the advent of new techniques, however, was taking place.

The evolution of exploration philosophies

has been primarily a matter of changes in the methods of managing exploration. For a very long time the average mining community was isolated, and even the large operations all began in isolation. In those circumstances the local mining engineer-mine manager was king. He had to know how to do almost anything and he did. All problems arrived in front of him immediately, and his solutions were fast and usually good.

As the isolation problem became uncommon and as the whole mining business became large, complex and, for the individual, specialized, the concept that the mine engineer-operator still should be the real decision maker prevailed for a remarkably long time.

At this point I'll bring up Kennecott—not because I know more about that company than the rumor mill normally provides—but because for such a long time they completely ignored exploration. It wasn't a technique, a philophy or a problem. Once in awhile a manager would point to an area on a map, some holes would be drilled, 10,648,321.4 tons of ore would be added to reserves and—so what is unusual?

In the late 30s the manager of one of their operations, and a nice guy nonetheless, gave me some friendly advice. I was working for a neighboring company; he knew me only slightly; but he could tell I was taking my job too seriously. He said "A geologist might be all right, but I prefer a churn drill."

In those days Kennecott could afford managers like that, but the breed flourished in many companies where it was ill-afforded.

As I remember it, sometime in the late 40s a well-known geologist named Anthony Gray (African experience mostly, I think) persuaded the Kennecott board to undertake a massive exploration program. That in itself was a full 180-degree turn, but the hard-to-believe part was the corporate managerial arrangement.

Bear Creek was set up as an exploration entity having no connection with the system of operating mine management.

Gray had retired, and I have no knowledge of his effect on policy beyond my understanding that he accomplished the establishment of Bear Creek. Jim Boyd, a mining administrator of established talent, but a far cry from the old-time mine operator boss, ran the show; and the size of his money supply was hard to believe.

I have never learned of any especial geological idea or combination of exploration techniques that motivated the formation of Bear Creek. So, my own thought is that Kennecott decided first to collect a big bunch of talented geologists, and the exploration ideas then were bound to evolve. They did.

Bear Creek people soon were all over the place. In many ways they influenced nearly all facets of porphyry copper exploration. For example, besides many geophysicists, geochemists, and photogeologists, they had field geologists specializing in regional reconnaissance, and others in detailed mapping, and scientists combining specialized field and sophisticated laboratory studies; they had mining engineers, mineralogists, geological researchers, statisticians, economists, computer programmers, drilling specialists, and so on.

I'm not necessarily expressing approval of all of the Bear Creek setup and procedures; but I do emphasize that their influence on the administration and methods adopted by other exploration organizations was pronounced.

Many exploration groups moved into the Southwest in the 50s and 60s. Some just intended to determine, briefly, what was going on. Most stayed to do a lot of reconnaissance work; and, because an array of technical improvements and new developments were just coming out in geophysics, geochemistry, and photogeology, they continued with projects. The detailed list is long under each of these headings of techniques; so a new group could quickly become involved in various combinations of these techniques—and many did just that.

Most groups concluded, too, that because they were covering new ground they should properly do their own geological mapping to back up whatever geophysical or other survey they might be conducting.

Thus, field work of many types was conducted over large tracts.

Despite the title of my talk I've no intention of commenting upon or even listing all of the activities and variations that could be considered as new or specialized exploration techniques used around here. There isn't time really to deal with the popular ones, let alone all of those which, in my opinion, either did not apply, or were overused. But I must mention a few factors that spurred and maintained exploration in the Southwest.

First, the real price of copper stayed ahead of all predictions, even if we average in a couple of episodes like the past year and a half.

Second, both the quality and quantity of publications on ore deposits and related geology in general and porphyry copper-molybdenum in particular increased remarkably in the past 20 years. Certain universities (the University of Arizona up with the top) and the USGS contributed most; some trade journals came out with surprisingly useful papers, and even private industry cut loose with some remarkable material on rare occasions.

Third, as the mining geologists became prospectors they learned that, despite the great amount of geological work of all kinds in the Southwest over the past 100 years, and particularly the last 30, there are still more uncertainties and complexities, though of different kinds, than 30 years ago. What appeals to me is that so many of these "new complexities" have relationships to exploration possibilities.

Of course, the high percentage of postmineral cover rocks in the Basin and Range province is always attractive to explorationists for many reasons.

Fourth, my friend who will be talking about case histories here tonight is certain not to deal properly with an episode which I believe had a most important effect on the exploration business.

Discovery always involves many people. Dave Lowell's Kalamazoo affair, however, was as close to being a one-man show as anything I know of. He demonstrated that the best of geological work may be subject to new or improved interpretations. This, however, requires logical thought, thoroughness, and time. Nowadays we have to hurry most of the time. I believe Dave showed us, however, that one of the keys to discovery is to know when to slow down and be thoughtful and thorough.

I'm constrained to add a precaution which you may find surprising. Certain lines of geological thought attain prominence as having possible value to exploration for one reason or another. Really, though, they are intellectual games, mostly. Please understand, I enjoy playing some of these games myself, but when exploration is involved a sharp distinction should be drawn between practical and impractical.

A couple of examples:

1. I am personally convinced that "lineaments," alignments, structural zones, or whatever the name, were important localizers of <u>some</u> porphyry copper deposits. But these structural conditions are very obscure in most cases and should be postulated only with care. A few years ago lines were being drawn all over the Southwest—the matter had become an intellectual game, and, as such, its real exploration value became obscured—almost valueless.

2. Plate tectonics is a wonderful subject of new scientific thought. But a tremendous amount of world-wide field work must be redone to improve its authenticity. Pictures of hydrothermal systems appear on sections of subduction zones. That alone is all right. But if there is a statement or an implication that up-to-date knowledge of plate tectonics will give me the longitude and latitude of a brand-new porphyry copper deposit in a year or two, I know we are playing intellectual games again.

All of us must use care in distinguishing the intellectual games from the practical aspects of geologic thought and conversation.

As an example of practicality, I would like to present my concept that the first real prospecting event occurred during pre-history. In case some of you are not up to date, pre-history is that gray area in time between recorded history and what I usually term "PB," or Post-Baboon. That terminology is easily confused with the newly accepted scientific initials "BP," or Before Present. I understand there is a group which maintains there <u>is</u> no time gap between Before Present and Post-Baboon.

Anyway—upon being pushed out of a tree an angry post-baboon—pre-person hurriedly picked up a chunk of yellow rock and threw it at her husband. It was heavy and knocked him cold. This so fascinated the pre-person (post-baboon, that is) that she took the summer off and went prospecting for another, bigger chunk of gold so she could really finish him off. I believe she was committed because a tribe of environmentalists discovered her prospecting license had expired.

PART 2. CASE HISTORIES OF DISCOVERIES [1]

by

J. David Lowell [2]

The period following World War II has seen a wave of porphyry copper discoveries in the Southwest with the bulk of these deposits having been found in southern Arizona. The attached tabulation of several selected features of each discovery has been prepared in an attempt to point up changes in techniques over this 33-year period, together with changes in the typical settings of deposits found.

A discussion of discoveries is always a subjective matter from the standpoint of who was responsible and which technique was responsible for the discovery. There are invariably rival claimants, however, the discovery typically results from a team effort of several different geologists, supported at different levels of management, sometimes aided by geophysists and geochemists, and often basing their work on regional geologic mapping, or stratigraphic or tectonic relationships worked out by geologists in government agencies. Peter Joralemon has pointed out in a recent paper that the contribution of prospectors or engineers or metallurgists is also the significant factor in many discoveries.

During the 33-year period covered by the tabulation (Table 1) fundamental changes have occurred in the parameters for porphyry copper exploration in the Southwest which are reflected to some extent in the tabulation. The most obvious change is the fact that, for practical purposes, all of the deposits have now been found in which the orebody, or the leached capping after ore, crops out. The deposits remaining to be found are those either completely covered by postmineral formations, or overlain by non-ore, premineral rocks, either in fault contact with ore or related to ore through vertical or lateral zoning relationships. Future discoveries will require greater use of indirect techniques—geologic projection, and geochemical and geophysical work, and perhaps most important, more exploration drilling per discovery, both in number of holes and average depth of holes. In a paper at the 1976 Annual AIME Meeting Schultz and Spat pointed out that the drilling cost per discovery has risen rapidly for the past several years.

Another factor which may loom larger than any other in the future is the question of the basic economics of porphyry copper mining in the Southwest. The price of copper in constant dollars diminished progressively during the period of 4000 B.C. to 1933, and then began to progressively increase. At the same time the minimum grade of ore which it was possible to mine progressively decreased from ancient times until the date of the most recent recession and the Middle East oil boycott and world energy crisis. Since that time the minimum minable ore grade has increased in both bulk underground, and open-pit copper mines. This trend could, of course, be reversed by a substantial increase in the price of copper, but this magnitude of increase is far from certain during the next few years. Most previous porphyry copper discoveries in the Southwest have been deposits which could be exploited as open pits. Most future discoveries will be potential underground mines, or in situ leaching situations. The ore habit in the Southwest favors deposits whose overall grade is less than 0.8% Cu. The San Manuel mine whose grade is about 0.72% Cu and 0.015% Mo could be taken as an example of the best type of deep, undiscovered deposit, which we are likely to find in the future. However, using current mining costs and present copper price a newly discovered, undeveloped San Manuel would not be a viable orebody. A copper grade of 0.9%-1.0% Cu, or a copper price of over $1.00 per pound would be required to make this hypothetical example a viable deposit. The increase in copper price is much more likely than finding the 1% plus copper deposit. If the price increase does not occur there will be few, if any, future discoveries of viable orebodies in the Southwest. Another effect of this factor is that there may be no longer be a tendency for known deposits to evolve into orebodies.

Exploration techniques which have been most successful in the Southwest have, as indicated by the tabulation, been geologic mapping and geologic interpretation, and leached capping interpretation. Geochemical and geophysical surveys have been of assistance in some discovery—the Pima orebody. Neither geochemical nor IP geophysical techniques are as effective in the Southwest as in western Canada and most other porphyry districts, because basin-range faulting has resulted in deep, postmineral valley fill; transported rath-

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[1] Banquet Address

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Table 1. United States tabulation of Southwest porphyry copper discoveries [1]

Porphyry Copper Deposit	Date(s) Discovered	Published or Estimated Tonnage And Grade Prior To Production[2]	Distance from Known Porphyry Copper When Discovered	Percent Outcrop of Ore Body or of Ore Leached Capping	Percent Post Ore Cover Over Ore Body	Geochemical Anomaly Useful In Outlining Ore Body	Geophysical Anomaly Useful in Outlining Ore Body
(1) San Manuel, Arizona	1917/1943	457,000,000 T 0.75 Cu	40 miles	± 5	± 95	Yes	Not used
(2) Safford-KCC, Arizona	1947/1955	500,000,000 T(+) 0.5(+) Cu	20 miles	30(?)	70(?)	Yes	Probably (IP)
(3) Tyrone, New Mexico	1920's/1950	±400,000,000 T 0.7 Cu	60 miles	±100	± 0	Yes	Probably not
(4) Pima, Arizona	1951	3,000,000 T(?) 0.5 Cu(?)	+60 miles	0	100	No	Yes (Magnetic)
(5) King Peak-Metcalf, Ariz.	1865/1952	±400,000,000 T(?) ±0.75 Cu(?)	1 mile	±100	± 0	Yes	Not used
(6) Imperial-Silver Bell, Ariz.	1909/1954	30,000,000 T(?) 0.75 Cu(?)	½ mile	± 10(?)	± 5	No	No
(7) Mission, Arizona	1954	200,000,000 T(+) ±0.75 Cu	1 mile	0	100	No	Uncertain
(8) San Xavier North, Ariz.	1955/1957	100,000,000 T(+) 0.5(+) Cu	2 miles	1(?)	99	No	Probably not
(9) Esperanza, Arizona	1955	150,000,000 T 0.68 Cu equiv.	8 miles	100	0	Yes	Uncertain (IP)
(10) Christmas, Arizona	1870/±1955	100,000,000 T(+) 0.4(+) Cu	15 miles	± 40	± 60	Yes	Uncertain (IP)
(11) Twin Buttes, Arizona	1957/1963	530,000,000 T(?) ±0.70 Cu	5 miles	0	100	No	Mag. trend hlpfl.
(12) Dos Pobres (P.D.), Safford, Arizona	1957	400,000,000 T(+) (?) 0.72 Cu(?)	±3 miles	± 25	± 75	Yes	Yes (IP)
(13) Ithica Peak, Arizona	1959	175,000,000 0.53 Cu	90 miles	±100	± 0	Yes	Possibly (IP)
(14) Sierrita, Arizona	1960/1963	±450,000,000 0.45 Cu equiv.	1½ miles	± 90	± 10	Yes	Probably (IP)
(15) East Helvetia (Rosemont), Arizona	1961	200,000,000 T(+) 0.7 Cu (?)	15 miles	± 10(?)	± 30(?)	Yes	Possibly (IP)
(16) Sacaton, Arizona	1961	±50,000,000 T 0.8(+) Cu	15 miles	0	100	No	No
(17) Battle Mtn., Nevada	1869/1961	50,000,000 T(+) 0.5(+) Cu	145 miles	±100	± 0	Probably	Uncertain
(18) Kalamazoo, Arizona	1965	500,000,000 T(+) 0.73 Cu	½ mile	0	± 50	Yes	Not used
(19) Vekol, Arizona	1965	75,000,000 T(?) 0.5(+) Cu(?)	±30 miles	0	90	No	Uncertain (IP)
(20) Copper Creek, Arizona	1966	50,000,000 T(+) (?) 0.7(+) Cu(?)	15 miles	0	0	No	Probably not (IP)
(21) Caridad, Mexico	1967	600,000,000 T 0.8 Cu	70 miles	100	0	Uncertain	Uncertain(IP)
(22) Copper Basin, Arizona	1920/1968	100,000,000 T(+) ±0.6 Cu eq.	35 miles	± 70	± 30	Yes	Probably (IP)
(23) Lakeshore, Arizona	1955/1968	472,000,000 T 0.76 Cu(?)	10 miles	± 10	± 90	Probably	Uncertain (IP)
(24) Poston Butte-Florence, Az.	1961/1970	400,000,000 T(?) 0.45 Cu(?)	±25 miles	0	100	No	Probably not (IP)
(25) Red Mountain, Ariz.	1970	ND	30 miles	0	0	Yes	No
(26) Hillsborough, N.M.	1930/1975	70,000,000 T(?) 0.7 Cu(?)	±40 miles	60	40	Yes	Uncertain (IP)

1. Includes Caridad (No. 21) in Mexico. 2. (?) Indicates uncertain data with only order-of-magnitude accuracy.

[1] Reprint from World Mining, 1976, v. 29, no. 11, by permission of the author.

Table 1. United States tabulation of Southwest porphyry copper discoveries—continued

Apparent Discovery Method	*Porphyry Copper Deposit*	
Geologic mapping and structural interpretation indicated that a small outcrop could expand downward into a large orebody	San Manuel, Arizona	(1)
Geologic mapping and interpretation of peripheral hydrothermal effects encouraged testing through postore volcanics	Safford-KCC, Arizona	(2)
Sampling and leached capping study. An old, higher grade underground mine evolved into a bulk low grade open pit	Tyrone, New Mexico	(3)
Geophysical survey on geologic projection located high magnetite skarn under postmineral gravel	Pima, Arizona	(4)
Leached capping interpretation and sampling indicated chalcocite orebody	King Peak-Metcalf, Arizona	(5)
Geologic interpretation and research of old mine records indicated possible hidden orebody	Imperial-Silver Bell, Arizona	(6)
Geologic interpretation and research of nearby mine openings and outcrop indicated possible extension of zone of alteration-mineralization at Pima	Mission, Arizona	(7)
Aerial reconnaissance located small outcrop of leached capping, and orebody found with offset drilling	San Xavier North, Arizona	(8)
Geologic mapping and leached capping study	Esperanza, Arizona	(9)
Sampling and geologic interpretation of old mineral prospect	Christmas, Arizona	(10)
Geologic interpretation based partly on magnetics, followed by wide-spaced offset drilling	Twin Buttes, Arizona	(11)
Geologic and leached capping interpretation of unusual outcrop and geochemical survey	Dos Pobres (P.D.), Safford, Arizona	(12)
Geologic and leached capping interpretation of old mineral prospect	Ithica Peak, Arizona	(13)
Geologic mapping and test drilling—old prospect evolved into orebody in part due to shifting economics	Sierrita, Arizona	(14)
Geologic and leached capping interpretation of old mineral prospect	East Helvetia (Rosemont), Arizona	(15)
Geologic reconnaissance program located small outcrop interpreted to be pyritic capping peripheral to orebody	Sacaton, Arizona	(16)
Old deposit which evolved into an orebody with geologic mapping, drilling and improvement in economics	Battle Mtn., Nevada	(17)
Geologic mapping and interpretation of structure and concentric zoning	Kalamazoo, Arizona	(18)
Geologic mapping and IP survey	Vekol, Arizona	(19)
Geologic interpretation of surface geology and re-interpretation of previous drilling	Copper Creek, Arizona	(20)
Leached capping and geologic interpretation	Caridad, Mexico	(21)
Geologic mapping and test drilling. Old prospect evolved into orebody	Copper Basin, Arizona	(22)
Geologic mapping and drilling done near fault segment orebody. Also IP survey	Lakeshore, Arizona	(23)
Geologic interpretation of peripheral outcrops followed by wide-space offset drilling	Poston Butte-Florence, Arizona	(24)
Geologic interpretation of vertical zoning followed by deep drilling	Red Mountain, Arizona	(25)
Geologic interpretation of previous drill data	Hillsborough, New Mexico	(26)

er than residual soils; and typically thick leached and oxidized zones which do not give an IP response. Both the IP and geochemical methods are best suited to a British Columbia environment of near-surface sulfides and shallow cover. As Southwest exploration progresses into deeper and deeper postmineral cover these methods will also tend to become less effective unless new and more reliable techniques can be developed.

The tabulation of discoveries indicates that seven of the last eleven deposits were essentially completely covered (one, Lakeshore, had 10 percent outcrop), and that since 1960, seven of the ten discoveries in Arizona have been completely covered. The percentage of covered discoveries is certain to increase in the future.

Reviewing some of the other factors on the tabulation we see that there were ten deposits discovered in the period 1943-1955, nine deposits discovered from 1955-1965, and seven deposits discovered after 1965. This suggests a progressive decrease in the success rate. It should be noted that many of the deposits have multiple discovery dates which reflect an earlier intersection of the mineralized body, and a later decision that it may represent a minable deposit—often by a different company. There seems to be no consistent variation in size of the deposits through the 33-year period, nor is there a noticeable change in the distance from a known porphyry. As mentioned, the amount of postmineral cover over discoveries has progressively increased through the period. Geochemical surveys appear to have been somewhat more useful than geophysical surveys, although geochemistry has never been the principal factor in a discovery as was the case for the Pima magnetometer survey. Geophysical surveys also have had some useful depth-of-cover and groundwater applications.

It's interesting to note that one orebody was found in an old company file cabinet, and one deposit was found by a re-interpretation of old drill data. Zoning interpretations and offset drilling are mentioned more frequently toward the bottom of the table as no more ore outcrops remain to be tested. Also almost every deposit was specifically discovered by a drill hole—whether drilled for the right reason or the wrong reason. There would have been very few discoveries without the drill rig, and the programs which never progressed from the "think stage" to the "drilling stage" were invariably doomed to failure.

It would perhaps be useful to select three deposits representative of the three decades covered by the tabulation and describe each to illustrate changes in settings and in successful exploration techniques over this period.

The first example is King Peak—Metcalf, immediately east of the Morenci—Clay orebody. This exploration target was identified in a careful and accurately interpreted leached capping study completed in 1952, and the first exploration hole intersected ore. The pre-discovery drilling cost of the project was very low. Tyrone would be a similar example, but no targets of this type now remain untested in the United States, although there may still be a few in Latin America and Iran and Pakistan.

The second example is the Sacaton deposit found near Casa Grande, Arizona in 1961. This discovery was one of several Asarco finds which resulted from a comprehensive district-wide program of geologic mapping in southern Arizona of features related to porphyry copper mineralization. This regional work tended to bridge the gap between theoretical and applied geology, particularly in the areas of stratigraphic and structural interpretation. Several holes at Sacaton were initially drilled as offsets around a small outcrop identified as being pyritic, but probably porphyry-copper-related, leached capping, before ore was intersected. Many additional drill holes were required before a viable orebody was confirmed, and the overall ratio of development drill footage to tons of ore developed was also high.

The third example is the Red Mountain deposit near Patagonia, Arizona, discovered in 1970, and described in a recent Economic Geology paper by Russ Corn. This is the deepest porphyry which has so far been found. It is in an area of premineral outcrop where shallow, sub-commercial mineral deposits have been known for many years. Discovery of the deep deposit resulted from persistent and thoughtful exploration to progressively deeper depths over a period of 12 years. The key to the discovery was vertical hydrothermal zoning theory. The pre-discovery driling expense was very large, and post-discovery drilling and development expense will be very large.

The conclusion from this review must be that deposits are becoming harder and more expensive to find. Most of our exploration tools become less effective with increase in thickness of postmineral cover. Recent shifts in copper economics have been a further obstacle; however, copper exploration, like the copper market, has always been a cyclic field, and many additional deposits remain under the Tertiary gravel and volcanics which will probably be discovered in the next 30-year period.

ARIZONA GEOLOGICAL SOCIETY DIGEST

VOLUME XI

Proceedings of the PORPHYRY COPPER SYMPOSIUM

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A SYMPOSIUM SPONSORED BY THE ARIZONA GEOLOGICAL SOCIETY
AND THE UNIVERSITY OF ARIZONA

TUCSON, ARIZONA / OCTOBER, 1978

KENYON RICHARDS, GEOLOGIST, DIES AT AGE 78

Kenyon E. Richard, former chief geologist for American Smelting and Refining Company (ASARCO), Inc., died on Saturday, October 30. He was 78.

Richard was known worldwide for his exploration and discovery of ore prospects, especially porphyry copper.

Richard, along with J. Harold Courtwright, now deceased, is credited with the geological work leading to the discovery and development of the major Arizona copper deposits of Silver Bell Oxide, Silver Bell El Tiro, Mission, North San Xavier and Sacaton.

In South America he was instrumental in the discovery of the Peruvian copper deposits of Quellaveco, Toquepala, Michiquillay, and Toro Mocha. In addition, he is credited with discovery of the Tayson copper deposit in the Philippines.

Richard was born in San Francisco, California to Mr. and Mrs. Leroy L. Richard of Visalia, California, on October 17, 1915. Richard graduated from Visalia High School where he was a track star, winning four gold medals in a single day of competition in the California Class "C" State Championship.

He graduated Magma Cum Laude and Phi Kappa Phi with a B.S. in geological engineering from the Mackay School of Mines at the University of Nevada in Reno in 1937. While there he was president of Blue Key, Sigma Nu and excelled in track, setting a record for the long jump that stood for more than 25 years. He was inducted in to Nevada Athletic Hall of Fame in 1977.

He joined Consolidated Coppermines Corp., in Ely, Nevada in 1937 as geologist.

Eight years later, he joined ASARCO in San Francisco. He moved to Tucson in 1953 where he was appointed chief geologist of ASARCO's Southwest Division. He was promoted as ASARCO's chief geologist to worldwide exploration exploration in 1963 and was transfered to New York City. He retired from ASARCO in 1967 and spent 11 years consulting throughout the world for Royal Dutch Shell, Exxon, United Nations and a variety of global mining companies.

Richard was a charter member of the Mining Club of the Southwest and was active in numerous other professional organizations, including the American Institute of Mining, Metallurgical and Petroleum Engineers, the Geological Society of America and the Arizona Geological Society. Over the years, he held leadership positions in all these organizations.
Richard was published in MINING GEOLOGY by H.F. McKinstry with a section on drilling and in numerous journals including MINING ENGINEERING.

He is survived by his wife Doris Richard of Phoenix, Arizona; son Kenyon E. Richard, Jr. and his wife Shirley of Phoenix, Arizona; daughter Sue R. Gould of Denver, Colorado; stepdaughter Nancy Bollard and her husband David of Phoenix, Arizona; stepson Anthony Buehl and his wife Becky of Scottsdale, Arizona; sister Constance Whitmore of Santa Barbara, California; 2 grandchildren; 2 step-grandchildren; and one step-great grandson.

A memorial service was held at Adair's Avalon Chapel in Tucson, Arizona.

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Kenyon E. Richard born October 17, 1915 San Francisco, Ca, died October 30, 1993 Tucson, Az.
REVIEW OF MEMORIAL FOR KENYON RICHARD ON NOVEMBER 5, 1993 CONDUCTED BY KENYON RICHARD, JR. AND HIS WIFE SHIRLEY AT ADAIR'S AVALON CHAPEL IN TUCSON, AZ.

KENYON RICHARD, JR. AND HIS WIFE SHIRLEY BROUGHT TOGETHER FRIENDS AND ASSOCIATES FROM COLLEGE DAYS AND A HALF-CENTURY OF AN OUTSTANDING PROFESSIONAL LIFE: THOSE WHO COULD NOT ATTEND WERE REMEMBERED AND RECOGNIZED FOR THEIR CONTRIBUTIONS TO HIS MEMORY.

THE SERVICE AT THE ADAIR AVALON CHAPEL IN NORTH TUCSON WAS A CELEBRATION BY ALL WITH VERBAL REMEMBERANCE BY FAMILY AND SOME WHO WERE EITHER FRIENDS FROM SCHOOL DAYS AND/OR FRIENDS AND PROFESSIONAL ASSOCIATES. MANY ADDITIONAL MUTUAL EXPERIENCES AND OTHER REMEMBERANCES WERE HEARD DURING THE FOLLOWING LUNCHEON.

KENYON'S EARLY DAYS IN VISALIA, CALIFORNIA EXPOSED HIM TO THE SIERRA MTS. NEAR THE SOUTHERN END OF THE MOTHER LODE GOLD BELT. THIS LED TO HIS JOINING THE MACKAY SCHOOL OF MINES AT THE UNIVERSITY OF NEVADA, RENO WHERE HE GRADUATED IN 1937.

KENYON'S FIRST JOB FOLLOWING GRADUATION WAS WITH CONSOLIDATED COPPER MINES CO. ELY, NEVADA. THIS CONTINUED HIS ASSOCIATION DURING SUMMER EMPLOYMENT. HIS REPUTATION THERE AS A DEDICATED PROFESSIONAL ORE-FINDER WAS FOLLOWED BY 34 YEARS WITH ASARCO WHICH AT THAT TIME WAS KNOWN AS THE AMERICAN SMELTING AND REFINING CO. OR AS&R.

KENYON AND HIS ASSOCIATE, HAROLD COURTRIGHT WERE LARGELY INFLUENTIAL IN THE EXPANDING OF THE SMELTING COMPANY TO A DISCOVERER AND MINER OF COPPER, LEAD, GOLD, SILVER AND OTHER ORES FROM ITS OWN MINES FOR ITS SMELTING AND REFINING OPERATIONS FOR CUSTOM ORE. THIS CREATION OF AN INTEGRATED PRODUCER OF METAL PRODUCTS FROM ITS OWN MINES OFTEN IN FINISHED PRODUCTS TO INDUSTRY BEGAN WITH THE SILVERBELL COPPER MINE NEAR TUCSON, ARIZONA.

EARLIER OPERATIONS OF SMALLER PRECIOUS AND BASE METAL MINES IN MEXICO AND THE WESTERN U.S.A. WERE AS IMPORTANT AS FLUX FOR THE SMELTING OF CUSTOM ORES AS FOR THE METAL CONTENT. THESE OPERATIONS WERE SOON OVERWHELMED BY THE PORPHYRY COPPER DEPOSITS ACQUIRED AND/OR DISCOVERED IN PERU AND ARIZONA. ASARCO WAS RESPONDING TO INCREASING COPPER PRICES AND GOVERNMENT ENCOURAGEMENT TO REPLACE RESERVES DIMINISHED BY THE DEMANDS OF THE RECENT 1941-1946 WORLD WAR.

DURING THE WAR MINES WERE REQUIRED TO PRODUCE KNOWN ORE IN AN ALLOUT EFFORT NOT TO BE DIMINISHED BY SEARCH FOR NEW ORE. FOLLOWING THE WAR, THE "PREMIUM PRICE PLAN" AMONG OTHER EFFORTS WAS CREATED BY CONGRESS TO SPEED METAL DISCOVERIES TO REPLENTISH RESERVES.

THE PERSPICACITY OF GEOLOGIST WALTER LANDWEHR IN ASARCO'S

SALTLAKE CITY. UTAH OFFICE POSITIONED KENYON RICHARD TO ASSIST THE DEVELOPMENT OF NEW RESERVES. TARGET: PORPHYRY COPPER.

AFTER A UNIQUE STUDY BY KENYON RICHARD OF COPPER AND PRECIOUS METAL POTENTIAL IN CALIFORNIA'S MOTHER LODE GOLD-COPPER DEPOSITS, ASARCO DECIDED TO DEVELOP THE WELL-KNOWN SILVERBELL COPPER PROSPECT NEAR TUCSON, AZ., A RECOGNIZED PORPHYRY COPPER DEPOSIT.

SILVERBELL HAD BEEN EARLIER STUDIED AND DRILLED FOR ITS COPPER CONTENT. KENYON'S AND HAROLD COURTRIGHT'S INTEREST AND SUCCESS IN THE STUDY OF MINERALIZATION AND STRUCTURE AT THE NEVADA COPPER DEPOSIT AT ELY WAS FOLLOWED BY KENYON'S STUDY OF LEACHED ORE OUTCROPS WITH ROLAND BLANCHARD. ASARCO SENT KENYON ON AN EXTENSIVE EXAMINATION OF OUTCROPS IN NORTH AND SOUTH AMERICA WITH BLANCHARD WHO WAS AN EARLY STUDENT OF THE SUBJECT.

KENYON JOINED HAROLD COURTRIGHT AT SILVERBELL, FOLLOWING THE MOTHER LODE SURVEY. TO MAKE AN ADDITIONAL STUDY OF THE EARLIER DRILLING AND MAPPING. THE RESULT QUALIFIED SILVERBELL AS ASARCO'S INITIAL EFFORT IN DISCOVERY AND PRODUCTION OF METAL RESERVES FOR ITS SMELTERS AND REFINERIES TO SUPPLEMENT ITS CUSTOM OPERATIONS.

TIMING WAS IMPORTANT FOR ASARCO'S FUTURE AS WELL AS FOR THESE TWO RELATIVELY NEW ORE-FINDERS OR "EDUCATED PROSPECTORS".

SUCCESS AT SILVERBELL WAS FOLLOWED IN RELATIVELY RAPID SUCCESSION BY SUCCESS IN DEVELOPMENT OF LARGE PORPHYRY COPPER DEPOSITS FROM KNOWN AND NEWLY-DISCOVERED OUTCROPS INTO PROFITABLE COPPER ORE DEPOSITS IN PERU.

DURING INTENSIVE AND SUCCESSFUL STUDIES IN PERU AND DEVELOPMENT OF SILVERBELL, THE DISCOVERY OF AN UNUSUAL PORPHYRY COPPER SYSTEM A FEW MILES SOUTH OF TUCSON, AZ. WAS MADE BY THE COMPETITION. THIS DISCOVERY WAS BY A TEAM OF MINING ENGINEERS AND GEOPHYCISTS ASSEMBLED BY ALAN HOOVER, SON OF MINING ENGINEER HERBERT HOOVER WHO PROGRESSED FROM FOOTBALL COACH AT STANFORD TO PRESIDENT OF THE U.S.A. AN ANOMALOUS MAGNETIC RESPONSE BENEATH 200 FT. OF GRAVEL ADJACENT TO A KNOWN SMALL COPPER OPERATION LEAD TO THE DISCOVERY OF COPPER MINERALIZATION IN SEDIMENTS WITH A DRILL HOLE: THIS BECAME THE PIMA MINE, A DISCOVERY BY UNITED GEOPHYSICS CO. LARGELY GUIDED BY WALTER HEINRICHS AND BOB THURMOND, TUCSON.

ASARCO'S ATTENTION OF THIS UNDRAMATIC DISCOVERY IN A DISTRICT KNOWN FOR ITS SMALL COPPER OCCURRENCES WAS NOTED BY GEOLOGIST-ORE BUYER FOR ASARCO, REED WELCH, AS SHIPMENTS OF PIMA'S COPPER ORE REACHED ASARCO'S EL PASO, TEXAS SMELTER. ASARCO WAS AMONG A VERY SMALL NUMBER OF INTERESTED MINING COMPANIES. AS A RESULT, ASARCO RECOGNIZED THE POTENTIAL FOR A LARGE PORPHYRY-TYPE COPPER SYSTEM, PRINCIPALLY IN SEDIMENTS WITH LITTLE OR NO KNOWN INTRUSIVE PORPHYRY EXPOSURES. THIS RESULTED IN ASARCO'S LEAD IN DISCOVERY OF LARGE COPPER RESERVES AS A DIRECT RESULT OF THE RICHARD-COURTRIGHT PORPHYRY COPPER SPECIALILST'S. THE MISSION MINE IN THE

DISCOVERY AREA IS STILL OPERATED BY ASARCO ON AN UNUSUAL PORPHYRY COPPER DEPOSIT IN SEDIMENTS WITH NO PORPHYRY' AND SPARCE OUTCROPS NEARLY COMPLETELY BURIED BY HUNDREDS OF FEET OF POST-ORE GRAVEL. THIS DISCOVERY IS WITHIN VIEW OF ASARCO'S (AS&R AT THAT DATE IN THE MID 1950'S) TUCSON OFFICE AND NEARLY INTERSECTING HIGHWAY 17 TO NOGALES FROM TUCSON. ASARCO'S EARLY RECOGNITION OF THE IMPORTANCE OF THIS DISCOVERY AS A PORPHYRY COPPER DEPOSIT RESULTED IN THEIR MAJOR SHARE OF THE DISTRICT'S COPPER RESERVES WITH MINIMAL INTERFERENCE FROM THE COMPETITION. PIMA MINE'S OPERATORS HAD NO OBJECTION TO ASARCO'S CLAIM LOCATIONS ADJACENT TO ITS CLAIMS. THIS ACTION FOLLOWED ASARCO'S STUDY OF THE PIMA MINES UNDERGROUND WORKINGS. ASARCO'S AND ARIZONA'S PREDOMINANCE IN THE NATION'S COPPER INDUSTRY WAS FURTHER ASSURED.

REMEMBERED BY LOCAL GEOLOGISTS IS THE NEAR DISCOVERY OF THIS MAJOR DISTRICT WAS NARROWLY MISSED YEARS EARLIER BY QUALIFIED EXPLORERS, THE EAGLE PITCHER MINING CO. THIS GROUP HAD THE RIGHT IDEA, AND NEARLY HIT THE TARGET. ASARCO COULD HAVE MISSED THIS MAJOR OPPORTUNITY WITHOUT THE INFLUENCE OF THE EL PASO SMELTER AND THE ALERT GEOLOGY-TRAINED ORE BUYER, REED WELCH. ORE-FINDERS ENJOY SUCCESS WITH QUALIFIED BACKUP SUPPLIED BY AN ALERT COMPANY.

THE PACE OF ASARCO'S EXPLORATION WAS EXPANDED TO TEN OR MORE COUNTRIES ADJACENT TO THE PACIFIC RIM AND AN EQUAL NUMBER OF SUCCESSFUL MINING DEVELOPMENTS.

ADDITIONAL DETAILS OF THE INFLUENCE OF ASARCO'S AND OTHERS WHO HAVE BEEN PROMINENT IN ORE-FINDING WILL BE SOON AVAILABLE. THIS INFORMATION WILL BE PRESENTED AT A SYMPOSIUM DEDICATED TO THE KENYON RICHARD-HAROLD COURTRIGHT TEAM.

INFORMATION USED FOR THIS REVIEW HAS BEEN LARGELY SUPPLIED BY ASARCO AND OTHERS WHO HAVE PUBLISHED OVER THE PAST HALF-CENTURY.

BYRON S. HARDIE AND JAMES D. SELL, TUCSON, AZ.

COPIES TO: JAMES D. SELL, ASARCO, TUCSON.
CLARE ROSCOE, MINING FOUNDATION OF THE SOUTHWEST, TUCSON.
MR/MRS KENYON RICHARD, JR., PHOENIX.
MRS. HAROLD COURTRIGHT, TUCSON.
MRS. JAN WILT, TUCSON.

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KENYON E. RICHARD
1915-1993

Kenyon started on the road of porphyry copper exploration in 1937 under E.N. Pennebaker, consulting geologist of Consolidated Coppermines Corporation at Ely, Nevada.

J.H. Courtright joined the Consolidated Coppermines group in 1941, and both he and Kenyon worked in the Ely, Nevada, and Safford, Arizona areas as well as investigating numerous other occurrences throughout western America.

In 1945, Kenyon joined the Western Mining Department of Asarco as Senior Geologist under W.R. Landwehr, as did Harold Courtright.

Their Bootprints have been left all along the Cordillera from Canada to South America and beyond, over the past 50 years.

Kenyon became Chief Geologist of the Tucson Office in 1953, staying in Tucson for ten years, before moving to New York as Chief Geologist, Asarco Exploration. He retired from Asarco in 1967 to open a consulting office.

During those 22 years of Asarco leadership, numerous studies were made in the major porphyry copper districts and papers published on the findings. Silver Bell, Arizona, 1948, was the first open-pit put into production by Asarco and the successful leached capping studies were a factor in drilling out the reserves. The following year, the Toquepala, Peru area with its breccia pipes and two cycle enrichment sequence was untangled and a large reserve drilled out. Several publications and presentations resulted in this work. At the Atlantic City meeting of SEG in 1969, Kenyon presented a paper on the "Process of formation of mineralized breccia pipes," and chaired the following day's session.

The study of the Toquepala breccias was slow and many words, relooking, more words, more looking, took place before an understanding emerged.

The outcrops at Toquepala were plotted by plain table & alidade. A story, as is told by the young engineer who was in charge of running the alidade, that on the first day he accurately plotted the outcrop position of Kenyon and Courtright early in the morning, but for the rest of the day they had not moved from the outcrop! Seems they hammered away, then peered through their hand lens, then verbiage followed, arms waved, obvious discussion, and the cycle repeated all day. He was too far away to hear what was going on, but suggested to his supervisor that perhaps he wasn't needed until they decided to move to the second outcrop, which they ultimately did.

The Mission Project in the early 1950's with sparse outcrop and lots of surrounding sand probably increased the price of Mallox, while Mission, South San Xavier, and North Xavier were found and delineated.

However, Mission was well exposed compared to Sacaton, NW of Casa Grande, where a small hill with encouraging capping was found in 1961. The nearest other unmineralized outcrops being nearly 2 miles away.

The last hole of the initial 6 hole drill program intercepted sufficient ore grade copper to keep the exploration going. Naturally the old quip about "Why didn't you drill the last hole first," was well passed around.

Chalcocite ore was cut off at depth by a flat fault at Sacaton and this pushed exploration outward into the desert and farmlands. The first hole was 1½ miles to the SW, the fourth hole was 6 miles away in the same direction and finding bedrock at 1400-2800 feet under the surface sands; but holes 5 & 6 were "over a cliff" and didn't find bedrock until 3600-4200 feet of drilling. The Asarco drilling engineer modestly stated that these holes were probably a record depth for diamond bit coring in uncased rotary holes in overburden. Kenyon's comment was: "Records such as these, we don't need!"

Kenyon's humor and observation on the "Explorationist-The Modern Prospector," and kindred subjects were expressed in a series of articles entitled "Wry on the Rocks," published in the mid-1970's after leaving Asarco.

Kenyon and his staff were the front-runners of Asarco's present Copper Operations -- Silver Bell, Sacaton, Mission Complex, with Silver Bell, Helvetia, Casa Grande West in the future, along with their share of Southern Peru Copper Corporation's Toquepala, Cuajone, Quellaveco and other deposits, and Mexico's MEDIMSA's Conception del Oro, Inguaran, La Caridad, El Arco and others. All have benefitted from the teachings of Kenyon on outcrop observation, interpretation, commitment, and purpose.

Kenyon -- we all thank you. Rest in Peace.

James D. Sell

James D. Sell
11/4/93

THIRTY-YEAR EVOLUTION OF PORPHYRY COPPER EXPLORATION IN SOUTHWEST USA[1]

PART 1. TECHNIQUES AND PHILOSOPHIES

by

Kenyon Richard[2]

More or less 30 years ago there was a gradual but profound change in mineral exploration —particularly in porphyry copper exploration.

Functioning for the first time in organized, systematized groups outside of their home districts, mining geologists themselves became regional prospectors.

In order to explain that last statement, I feel that I must go back, not just 30 years, but into the last century, even earlier, for a number of comparisons, because the contrast in exploration procedures is distinct; and by no means are the distinctions all due to new technological capabilities.

Through very early Biblical times, and the Cypriots, Romans, and Conquistadores, to name a few, the prospector-miners were slaves. That's low-cost operation at its lowest, particularly because the families of the slaves had to feed them.

The Queen of Sheba is a good example of ingenuity. She operated a lode gold mine. The slaves who rotated her hand ore grinders were blinded. Even if they did find nuggets, they couldn't escape. She certainly needed no time-motion analyst to explain the meaning of operational efficiency. Her biggest headache probably was maintaining a monopoly on the slave market because her labor turn-over must have been high due to early insanity among the workers.

The first "free" prospectors in history were the California '49ers. They were free, that is, to blister in summer, freeze in winter and starve year-round. On average they barely made wages. But they came from all over the world and they didn't return home when the placer gold deposits were soon worked out. Some became ranchers, store owners, blacksmiths, and the like, and most prospered; but some took their California gold pans, spread out over the West, learned to detect other heavy minerals and metals, and taught themselves and their successors a few characteristics of ore deposits. These men became the prospectors, and a very few of them became the discoverers of bonanzas, the real founders of the burgeoning mining business of the West.

However, most of them ruined themselves with hard, useless work because they lacked education—even the rudiments of business, engineering, or geology—partly because it was not available, but mostly because they were too rough-hewn to have bothered with it anyway. Consequently, they tended to regard almost any mineral showing as a probable orebody; they simply did not recognize the tremendous odds against success; they were imbued with the Western tradition of toughness; and they were sustained by that marvelous incentive for human endeavor: the dream of instant wealth. Altogether, the thousands of miles of hand-driven workings on worthless mineral showings is staggering to contemplate.

They found many thousands of mineral deposits. But with the exception of those few bonanzas, the instant wealth didn't materialize.

Most of the prospectors realized rather early they could not convert the discoveries of seemingly fairly good mineral showings into instant wealth either by themselves or in hard-working small groups. To some of the discoverers it became evident that the making of mines required talents and resources they lacked: First, an understanding of geology such that a discovery could be evaluated without blindly undertaking a terrible amount of fruitless hard work; second, an appreciation of mining engineering, management, marketing, etc; and most important, a supply of money and knowledge of its use.

The bonanza discoveries, of course, early attracted money along with engineering and management talent. When the ore was rich, however, the mine operators could and did make many expensive exploration blunders—unnoticed. So, recognition by anyone of a need for knowledge of the geology of mineral deposits evolved very slowly.

The earliest individuals doing "mining"

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[1] Banquet Address

[2] 11 E. Orange Grove Rd., Tucson, Arizona 85704

geological work of a special kind—for example, men like Becker and Hague of the Survey who published classics respectively on the Eureka and Comstock Lode districts of Nevada in 1882 and '83—were only scientific observers and describers, educated in Europe—and they worked only on the known bonanza deposits.

The same can be said for the next generation of geniuses, such as Ransome and Lindgren. They were marvelous scientific observers; they were not discoverers; but they were teachers, inasmuch as their publications and their fame improved and speeded the movement of the knowledge of mineral ore occurrences from European universities to eastern United States and on to the West.

Rather tardily, mining geology became available in the West. The more progressive mining companies began to hire men with education in the science of mineralization. Their exploration judgment gradually began to replace the whims of the mine shifters, the superintendents, the surveyors, the astrologers, and the like.

Anaconda formed the first and justly famous geological department. Other companies, large and medium sized, imitated Anaconda because of its reputed great success in ore finding. These new departments in other companies also found ore. The very important point here is that these departments of mining geology and their increasing knowledge of ore occurrence primarily functioned to find ore in company-owned mines, properties and districts. With the exception of checking out some prospects brought to their attention, no mining geologists really were prospecting for new districts in a regional sense—at least, they were not getting far from home base.

The rapidly improving knowledge about mineralization was still not directly available to to the prospectors. As time went on they still did not understand, themselves, really how to evaluate a newly discovered mineral showing, or for that matter, how to check out an old prospect in light of new economic conditions.

So—a technique evolved which had innumerable variations and ramifications and which I can only crudely describe here.

I term it the "walking through the door" technique. After digging around a bit on a new discovery—or possibly opening up the workings of an old prospect acquired with his second cousin's life savings—the prospector collected a few samples and specimens and went in search of the right office door to walk through. This might be the office of a nearby small mine manager, or the friend of a friend who knew a fellow who . . . , etc., or a lawyer, or a promoter who knew a mining vice president. Briefly, he had to get through a door behind which was the right combination of money and exploration-mining talent. This usually meant a medium-to-large company.

If he walked through that right door, it only meant that his mineral showing would get a proper evaluation, hopefully favorable and with a follow-up. If not, there were other mining company doors. Otherwise, there were doors such as stockbrokers'. In those days money from stock sales seldom involved much in the way of preliminary evaluation of a prospect; blatant misrepresentation was common; but money from valid stock sales did find and develop many orebodies.

The implication is not intended that the men with exploration and mining talent and the money managers were hiding behind their doors doing nothing but wait for bonanzas to walk in. They were quite busy with their own mines. Rather, and this is the whole point, the prospectors and promoters were keeping the mining companies sufficiently supplied with "outside" prospects worth the gambles of exploration and development. As a result the supply of base metals was being augmented enough to keep up with the demands of the growing industrial revolution. The mining geologists not only lacked the time, it wasn't even necessary for them to become real regional prospectors outside of their home mines and districts.

This system worked even though it grew accidentally; it was unorganized and haphazard, and it was unfair to the prospectors. It worked because the successive generations of prospectors had those recurring visions of the rainbow's end. Even if the rudiments of knowledge about mineral occurrences—and their vagaries—had been available to the prospectors of, say, 70 and 100 years ago, they wouldn't have listened because, if I may repeat myself for emphasis, all of those men were motivated by the delusive incentive of instant wealth.

The walking-through-the-door system was still functioning—willy-nilly, but effectively—when I got out of college. And in one form or another it will always be part of the business.

The first organized exploration program in history was undertaken, I believe, when World War II was looming and the U.S. military was shocked (and probably indignant) to learn that God had not provided instant domestic orebodies of quite all the minerals and metals the generals wanted for a new war. No brilliant exploration ideas seem to be immediately at hand, so the government reacted by

legislating instructions to the U.S. Bureau of Mines to find orebodies of seven strategic metals and minerals. For at least two reasons this was a dirty trick on the Bureau: First, they didn't really have good reasons to know where and how to explore for new supplies of these strategic items; and second, being very conscientious mining engineers, they thought they were supposed to know.

The Survey was fitted into some advisory capacity to the side and provided considerable help, so I understand, particularly when another law enhanced the problems by adding six more short-supply items.

A massive bureaucratic effort was made in which there was a great rejuvenation of interest in prospects and properties, practically all of which had already been turned down as too risky by private companies, usually by several, but, mind you, always on the basis of non-wartime economics . . . A new "through the door" procedure developed. It became a mad dash, not a walk, because the exploration money was not only free, it was wrapped in patriotism. Despite this frenetic atmosphere, the basics of the old system still prevailed. The prospector, or mineral property owner, or small-mine owner still had to get the attention of the experts behind the door. This time the door was government. The experts were more concerned with the collection and accuracy of details, but somewhat less concerned with exploration risks.

Despite the Bureau's mandate, which could have invited some pretty wild exploration, prospects and properties were checked thoroughly. Many drilling risks were taken, but only with care and thought. A few tons of ore were found here and there, but only one real discovery—San Manuel—resulted from the entire program, and that was too late to benefit the war effort. B. S. Butler of the University of Arizona and earlier USGS fame, and Nels Peterson, USGS, were the instigators of that discovery.

Considering their sincere efforts, the men conducting that major wartime exploration project deserved more luck. If viewed strictly from a commercial standpoint the program failed. The profit from ore found was small as compared with the program's cost. But, of course, it was not really supposed to be a commercial success. From philosophic and scientific aspects, however, I believe it was successful. It had only a few new geologic concepts for original impetous, but the published results eventually were of great value to future workers.

The big changes in exploration, particularly porphyry copper exploration in the Southwest, took place after World War II. The results of the Bureau and Survey programs had an effect; but the changes were not directly related to the war's end or to dramatic economic changes, or, since Ralph Nader hadn't arrived yet, to any great public outcry that something had to be done about something.

Rather, the realization gradually evolved in the minds of a few that, at least in the case of porphyry copper, it was possible that neither the prospectors nor the earlier geologists had really known how to find any but the rather obvious ore districts. The San Manuel discovery probably had some effect on this line of thought. This meant that (1) some other porphyry copper orebodies could be around somewhere and (2) the mining geologists had to re-do the copper prospecting job themselves.

There were other factors related to the changing copper exploration philosophy, and I'll get to those momentarily. First, though, let me indulge in a bit of narrative because I was involved somewhat myself. If you haven't already, you will note some difficulty in my being objective about a philosophy which is mostly subjective anyway.

E. N. Pennebaker, as consulting geologist for Consolidated Coppermines Corp., originated and conducted the first systematic program of regional prospecting for porphyry copper orebodies in the Southwest. It was begun in '48 and continued until '52 when the company was beginning to fold.

Penny had a staff of four to six young but excellent geologists. Ray Ludden, now manager of western exploration for Phelps Dodge, was one of the group. Their specific objective was to find new porphyry copper alteration zones. They used the state map to spot Laramide intrusives and they combed the Mines Handbook for leads like FeO-cemented gravels and for fringe manganese deposits like Bisbee and Ely. They jeeped and walked all over the place. They found about a dozen porphyry copper deposits not known as such theretofore, although a couple were near known porphyry districts. After finding an alteration zone, they would map in detail with particular attention to leached capping interpretation.

They drilled several holes in each of four, which I'll identify as Safford, Kelvin, Patagonia, and Yerington. I believe they penetrated ore-grade material in all four and they had one drill hole in the middle of what is now Kennecott's big Safford orebody. That's a pretty good record considering that they were constrained with the need for a +1.0% Cu orebody at a 0.6% cutoff. The copper price

didn't jump quite soon enough for them, that's all. They were mining geologists who became the first organized group that didn't wait for a porphyry copper prospect to walk through the office door.

While working at Silver Bell and then in southern Peru in the late '40s on some of those copper deposits, particularly Toquepala, Harold Courtright and I began to realize that green copper-stained outcrops could be seriously misleading in terms of copper sulfide ore occurrence. (By cutting myself in on this, I'm stretching things a bit because, as I suppose some of you know, I'm color blind—green copper stain comes through as a nice clean gray—so, I wasn't mapping the stuff anyway.) I did, however, contribute in various ways. I can assure you there was no great flash of insight involved. In fact, there were many complicated aspects of Toquepala geology: We were busy disagreeing about a lot of these other things, and I don't believe we began to think much about the copper-stain business until later when I had had a chance conversation with Juan Oviedo, the original owner of Toquepala. It then became evident that Cerro de Pasco had almost walked away from Toquepala without testing the sulfide zone. Apparently they thought the copper-stained outcrops were the guide to ore. What I want to emphasize is that, if Cerro had walked away, Southern Peru might today still be a rugged, discouraging desert with 2 or 3 billion tons of untested copper ore.

A steep-walled canyon cut the middle of the Toquepala deposit. A few small patches of weak copper-staining occurred high on the canyon walls in the fringe zones of alteration. Cerro had driven about eight adits, 250 m each, beneath these surface copper showings. They cut no sulfides and their adit assays were sometimes as high as 0.1% Cu. They were prepared to move out their camp. So, in desperation rather than with knowledge, Oviedo sank a shaft in the bottom of the canyon. Within 15 m his shaft encountered disseminated chalcocite averaging 4.0% Cu. Cerro stopped packing and started drilling.

Actually, Harold and I were rather slow to catch on. But we began to discuss the possibility that porphyry copper sulfide ore easily could occur in many other places without the need for directly overlying copper-stained outcrops.

The idea was simple, but a lot of other geologists had not caught on either. I worked with Blanchard for several weeks in '47 and I've talked with Locke and Tunell. I believe they all thought of the technique of leached outcrop interpretation, which they originated, as being useful in finding more ore in already discovered districts. It seems rather incredible, but I don't believe they considered it as being a means of discovering entirely new, separate deposits or districts by re-prospecting large regions. None of their publications state this as a possibility.

Anyway, Courtright and I thought the idea was important enough to warrant re-prospecting the Southwest United States and many other regions.

American Smelting didn't exactly respond with alacrity to my report describing how this prospecting should be done. While working on the Flux mine in the Patagonia Mountains, however, Courtright recognized porphyry copper alteration without copper stain, and I was sent to check it out early in '51.

That's where we ran headlong into our old friend Pennebaker and his crew. We had worked for Penny in the 30s and 40s at Ely, and we knew Ray Ludden and others of his crew. Also, Phil Jenney, representing Coppermines' partner, American Metals, used to show up frequently. We all stayed at the same motel and, as you can imagine, altogether there was quite a bit of socializing while we were stealing secrets from each other.

Of course, it was immediately evident that, although arrived at independently, our basic exploration ideas and Pennebaker's were about the same, only he was three years ahead of us.

Anyway, between Patagonia and the border there were plenty of porphyry copper alteration zones and breccia pipes for everyone. A number of holes were drilled, but there was no significant chalcocite enrichment. We all pulled out. Too bad none of us had the instincts of real estate operators. In terms of one kind of exploration philosophy and how it changed, everyone then was using about 18¢ copper when making projections into the dim, distant future of, say 1960 or '65.

I've dealt with the leached-capping-without-copper-stain idea rather at length because, although a simple geological idea, it had been overlooked. It got some drilling programs started. In turn, that activity got other groups interested. And so on.

Also, though, at about that time important new geophysical, geochemical, and other techniques were appearing and adding significantly to the changes in exploration. A change more important than the advent of new techniques, however, was taking place.

The evolution of exploration philosophies

has been primarily a matter of changes in the methods of managing exploration. For a very long time the average mining community was isolated, and even the large operations all began in isolation. In those circumstances the local mining engineer-mine manager was king. He had to know how to do almost anything and he did. All problems arrived in front of him immediately, and his solutions were fast and usually good.

As the isolation problem became uncommon and as the whole mining business became large, complex and, for the individual, specialized, the concept that the mine engineer-operator still should be the real decision maker prevailed for a remarkably long time.

At this point I'll bring up Kennecott—not because I know more about that company than the rumor mill normally provides—but because for such a long time they completely ignored exploration. It wasn't a technique, a philophy or a problem. Once in awhile a manager would point to an area on a map, some holes would be drilled, 10,648,321.4 tons of ore would be added to reserves and—so what is unusual?

In the late 30s the manager of one of their operations, and a nice guy nonetheless, gave me some friendly advice. I was working for a neighboring company; he knew me only slightly; but he could tell I was taking my job too seriously. He said "A geologist might be all right, but I prefer a churn drill."

In those days Kennecott could afford managers like that, but the breed flourished in many companies where it was ill-afforded.

As I remember it, sometime in the late 40s a well-known geologist named Anthony Gray (African experience mostly, I think) persuaded the Kennecott board to undertake a massive exploration program. That in itself was a full 180-degree turn, but the hard-to-believe part was the corporate managerial arrangement.

Bear Creek was set up as an exploration entity having no connection with the system of operating mine management.

Gray had retired, and I have no knowledge of his effect on policy beyond my understanding that he accomplished the establishment of Bear Creek. Jim Boyd, a mining administrator of established talent, but a far cry from the old-time mine operator boss, ran the show; and the size of his money supply was hard to believe.

I have never learned of any especial geological idea or combination of exploration techniques that motivated the formation of Bear Creek. So, my own thought is that Kennecott decided first to collect a big bunch of talented geologists, and the exploration ideas then were bound to evolve. They did.

Bear Creek people soon were all over the place. In many ways they influenced nearly all facets of porphyry copper exploration. For example, besides many geophysicists, geochemists, and photogeologists, they had field geologists specializing in regional reconnaissance, and others in detailed mapping, and scientists combining specialized field and sophisticated laboratory studies; they had mining engineers, mineralogists, geological researchers, statisticians, economists, computer programmers, drilling specialists, and so on.

I'm not necessarily expressing approval of all of the Bear Creek setup and procedures; but I do emphasize that their influence on the administration and methods adopted by other exploration organizations was pronounced.

Many exploration groups moved into the Southwest in the 50s and 60s. Some just intended to determine, briefly, what was going on. Most stayed to do a lot of reconnaissance work; and, because an array of technical improvements and new developments were just coming out in geophysics, geochemistry, and photogeology, they continued with projects. The detailed list is long under each of these headings of techniques; so a new group could quickly become involved in various combinations of these techniques—and many did just that.

Most groups concluded, too, that because they were covering new ground they should properly do their own geological mapping to back up whatever geophysical or other survey they might be conducting.

Thus, field work of many types was conducted over large tracts.

Despite the title of my talk I've no intention of commenting upon or even listing all of the activities and variations that could be considered as new or specialized exploration techniques used around here. There isn't time really to deal with the popular ones, let alone all of those which, in my opinion, either did not apply, or were overused. But I must mention a few factors that spurred and maintained exploration in the Southwest.

First, the real price of copper stayed ahead of all predictions, even if we average in a couple of episodes like the past year and a half.

Second, both the quality and quantity of publications on ore deposits and related geology in general and porphyry copper-molybdenum in particular increased remarkably in the past 20 years. Certain universities (the University of Arizona up with the top) and the USGS contributed most; some trade journals came out with surprisingly useful papers, and even private industry cut loose with some remarkable material on rare occasions.

Third, as the mining geologists became prospectors they learned that, despite the great amount of geological work of all kinds in the Southwest over the past 100 years, and particularly the last 30, there are still more uncertainties and complexities, though of different kinds, than 30 years ago. What appeals to me is that so many of these "new complexities" have relationships to exploration possibilities.

Of course, the high percentage of postmineral cover rocks in the Basin and Range province is always attractive to explorationists for many reasons.

Fourth, my friend who will be talking about case histories here tonight is certain not to deal properly with an episode which I believe had a most important effect on the exploration business.

Discovery always involves many people. Dave Lowell's Kalamazoo affair, however, was as close to being a one-man show as anything I know of. He demonstrated that the best of geological work may be subject to new or improved interpretations. This, however, requires logical thought, thoroughness, and time. Nowadays we have to hurry most of the time. I believe Dave showed us, however, that one of the keys to discovery is to know when to slow down and be thoughtful and thorough.

I'm constrained to add a precaution which you may find surprising. Certain lines of geological thought attain prominence as having possible value to exploration for one reason or another. Really, though, they are intellectual games, mostly. Please understand, I enjoy playing some of these games myself, but when exploration is involved a sharp distinction should be drawn between practical and impractical.

A couple of examples:

1. I am personally convinced that "lineaments," alignments, structural zones, or whatever the name, were important localizers of <u>some</u> porphyry copper deposits. But these structural conditions are very obscure in most cases and should be postulated only with care. A few years ago lines were being drawn all over the Southwest—the matter had become an intellectual game, and, as such, its real exploration value became obscured—almost valueless.

2. Plate tectonics is a wonderful subject of new scientific thought. But a tremendous amount of world-wide field work must be redone to improve its authenticity. Pictures of hydrothermal systems appear on sections of subduction zones. That alone is all right. But if there is a statement or an implication that up-to-date knowledge of plate tectonics will give me the longitude and latitude of a brand-new porphyry copper deposit in a year or two, I know we are playing intellectual games again.

All of us must use care in distinguishing the intellectual games from the practical aspects of geologic thought and conversation.

As an example of practicality, I would like to present my concept that the first real prospecting event occurred during pre-history. In case some of you are not up to date, pre-history is that gray area in time between recorded history and what I usually term "PB," or Post-Baboon. That terminology is easily confused with the newly accepted scientific initials "BP," or Before Present. I understand there is a group which maintains there <u>is</u> no time gap between Before Present and Post-Baboon.

Anyway—upon being pushed out of a tree an angry post-baboon—pre-person hurriedly picked up a chunk of yellow rock and threw it at her husband. It was heavy and knocked him cold. This so fascinated the pre-person (post-baboon, that is) that she took the summer off and went prospecting for another, bigger chunk of gold so she could really finish him off. I believe she was committed because a tribe of environmentalists discovered her prospecting license had expired.

PART 2. CASE HISTORIES OF DISCOVERIES [1]

by

J. David Lowell [2]

The period following World War II has seen a wave of porphyry copper discoveries in the Southwest with the bulk of these deposits having been found in southern Arizona. The attached tabulation of several selected features of each discovery has been prepared in an attempt to point up changes in techniques over this 33-year period, together with changes in the typical settings of deposits found.

A discussion of discoveries is always a subjective matter from the standpoint of who was responsible and which technique was responsible for the discovery. There are invariably rival claimants, however, the discovery typically results from a team effort of several different geologists, supported at different levels of management, sometimes aided by geophysists and geochemists, and often basing their work on regional geologic mapping, or stratigraphic or tectonic relationships worked out by geologists in government agencies. Peter Joralemon has pointed out in a recent paper that the contribution of prospectors or engineers or metallurgists is also the significant factor in many discoveries.

During the 33-year period covered by the tabulation (Table 1) fundamental changes have occurred in the parameters for porphyry copper exploration in the Southwest which are reflected to some extent in the tabulation. The most obvious change is the fact that, for practical purposes, all of the deposits have now been found in which the orebody, or the leached capping after ore, crops out. The deposits remaining to be found are those either completely covered by postmineral formations, or overlain by non-ore, premineral rocks, either in fault contact with ore or related to ore through vertical or lateral zoning relationships. Future discoveries will require greater use of indirect techniques—geologic projection, and geochemical and geophysical work, and perhaps most important, more exploration drilling per discovery, both in number of holes and average depth of holes. In a paper at the 1976 Annual AIME Meeting Schultz and Spat pointed out that the drilling cost per discovery has risen rapidly for the past several years.

Another factor which may loom larger than any other in the future is the question of the basic economics of porphyry copper mining in the Southwest. The price of copper in constant dollars diminished progressively during the period of 4000 B.C. to 1933, and then began to progressively increase. At the same time the minimum grade of ore which it was possible to mine progressively decreased from ancient times until the date of the most recent recession and the Middle East oil boycott and world energy crisis. Since that time the minimum minable ore grade has increased in both bulk underground, and open-pit copper mines. This trend could, of course, be reversed by a substantial increase in the price of copper, but this magnitude of increase is far from certain during the next few years. Most previous porphyry copper discoveries in the Southwest have been deposits which could be exploited as open pits. Most future discoveries will be potential underground mines, or in situ leaching situations. The ore habit in the Southwest favors deposits whose overall grade is less than 0.8% Cu. The San Manuel mine whose grade is about 0.72% Cu and 0.015% Mo could be taken as an example of the best type of deep, undiscovered deposit, which we are likely to find in the future. However, using current mining costs and present copper price a newly discovered, undeveloped San Manuel would not be a viable orebody. A copper grade of 0.9%-1.0% Cu, or a copper price of over $1.00 per pound would be required to make this hypothetical example a viable deposit. The increase in copper price is much more likely than finding the 1% plus copper deposit. If the price increase does not occur there will be few, if any, future discoveries of viable orebodies in the Southwest. Another effect of this factor is that there may be no longer be a tendency for known deposits to evolve into orebodies.

Exploration techniques which have been most successful in the Southwest have, as indicated by the tabulation, been geologic mapping and geologic interpretation, and leached capping interpretation. Geochemical and geophysical surveys have been of assistance in some discovery—the Pima orebody. Neither geochemical nor IP geophysical techniques are as effective in the Southwest as in western Canada and most other porphyry districts, because basin-range faulting has resulted in deep, postmineral valley fill; transported rath-

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[1] Banquet Address

[2] Pillar, Lowell & Associates, Tucson, Arizona 85704

Table 1. United States tabulation of Southwest porphyry copper discoveries [1]

Porphyry Copper Deposit	Date(s) Discovered	Published or Estimated Tonnage And Grade Prior To Production[2]	Distance from Known Porphyry Copper When Discovered	Percent Outcrop of Ore Body or of Ore Leached Capping	Percent Post Ore Cover Over Ore Body	Geochemical Anomaly Useful In Outlining Ore Body	Geophysical Anomaly Useful in Outlining Ore Body
(1) San Manuel, Arizona	1917/1943	457,000,000 T 0.75 Cu	40 miles	± 5	± 95	Yes	Not used
(2) Safford-KCC, Arizona	1947/1955	500,000,000 T(+) 0.5(+) Cu	20 miles	30(?)	70(?)	Yes	Probably (IP)
(3) Tyrone, New Mexico	1920's/1950	±400,000,000 T 0.7 Cu	60 miles	±100	± 0	Yes	Probably not
(4) Pima, Arizona	1951	3,000,000 T(?) 0.5 Cu(?)	+60 miles	0	100	No	Yes (Magnetic)
(5) King Peak-Metcalf, Ariz.	1865/1952	±400,000,000 T(?) ±0.75 Cu(?)	1 mile	±100	± 0	Yes	Not used
(6) Imperial-Silver Bell, Ariz.	1909/1954	30,000,000 T(?) 0.75 Cu(?)	½ mile	± 10(?)	± 5	No	No
(7) Mission, Arizona	1954	200,000,000 T(+) ±0.75 Cu	1 mile	0	100	No	Uncertain
(8) San Xavier North, Ariz.	1955/1957	100,000,000 T(+) 0.5(+) Cu	2 miles	1(?)	99	No	Probably not
(9) Esperanza, Arizona	1955	150,000,000 T 0.68 Cu equiv.	8 miles	100	0	Yes	Uncertain (IP)
(10) Christmas, Arizona	1870/±1955	100,000,000 T(+) 0.4(+) Cu	15 miles	± 40	± 60	Yes	Uncertain (IP)
(11) Twin Buttes, Arizona	1957/1963	530,000,000 T(?) ±0.70 Cu	5 miles	0	100	No	Mag. trend hi/fl.
(12) Dos Pobres (P.D.), Safford, Arizona	1957	400,000,000 T(+)(?) 0.72 Cu(?)	±3 miles	± 25	± 75	Yes	Yes (IP)
(13) Ithica Peak, Arizona	1959	175,000,000 0.53 Cu	90 miles	±100	± 0	Yes	Possibly (IP)
(14) Sierrita, Arizona	1960/1963	±450,000,000 0.45 Cu equiv.	1½ miles	± 90	± 10	Yes	Probably (IP)
(15) East Helvetia (Rosemont), Arizona	1961	200,000,000 T(+) 0.7 Cu (?)	15 miles	± 10(?)	± 30(?)	Yes	Possibly (IP)
(16) Sacaton, Arizona	1961	±50,000,000 T 0.8(+) Cu	15 miles	0	100	No	No
(17) Battle Mtn., Nevada	1869/1961	50,000,000 T(+) 0.5(+) Cu	145 miles	±100	± 0	Probably	Uncertain
(18) Kalamazoo, Arizona	1965	500,000,000 T(+) 0.73 Cu	½ mile	0	± 50	Yes	Not used
(19) Vekol, Arizona	1965	75,000,000 T(?) 0.5(+) Cu(?)	±30 miles	0	90	No	Uncertain (IP)
(20) Copper Creek, Arizona	1966	50,000,000 T(+) (?)0.7(+) Cu(?)	15 miles	0	0	No	Probably not (IP)
(21) Caridad, Mexico	1967	600,000,000 T 0.8 Cu	70 miles	100	0	Uncertain	Uncertain(IP)
(22) Copper Basin, Arizona	1920/1968	100,000,000 T(+) ±0.6 Cu eq.	35 miles	± 70	± 30	Yes	Probably (IP)
(23) Lakeshore, Arizona	1955/1968	472,000,000 T 0.76 Cu(?)	10 miles	± 10	± 90	Probably	Uncertain (IP)
(24) Poston Butte-Florence, Az.	1961/1970	400,000,000 T(?) 0.45 Cu(?)	±25 miles	0	100	No	Probably not (IP)
(25) Red Mountain, Ariz.	1970	ND	30 miles	0	0	Yes	No
(26) Hillsborough, N.M.	1930/1975	70,000,000 T(?) 0.7 Cu(?)	±40 miles	60	40	Yes	Uncertain (IP)

1. Includes Caridad (No. 21) in Mexico. 2. (?) Indicates uncertain data with only order-of-magnitude accuracy.

[1] Reprint from World Mining, 1976, v. 29, no. 11, by permission of the author.

Table 1. United States tabulation of Southwest porphyry copper discoveries—continued

Apparent Discovery Method	*Porphyry Copper Deposit*	
Geologic mapping and structural interpretation indicated that a small outcrop could expand downward into a large orebody	San Manuel, Arizona	(1)
Geologic mapping and interpretation of peripheral hydrothermal effects encouraged testing through postore volcanics	Safford-KCC, Arizona	(2)
Sampling and leached capping study. An old, higher grade underground mine evolved into a bulk low grade open pit	Tyrone, New Mexico	(3)
Geophysical survey on geologic projection located high magnetite skarn under postmineral gravel	Pima, Arizona	(4)
Leached capping interpretation and sampling indicated chalcocite orebody	King Peak-Metcalf, Arizona	(5)
Geologic interpretation and research of old mine records indicated possible hidden orebody	Imperial-Silver Bell, Arizona	(6)
Geologic interpretation and research of nearby mine openings and outcrop indicated possible extension of zone of alteration-mineralization at Pima	Mission, Arizona	(7)
Aerial reconnaissance located small outcrop of leached capping, and orebody found with offset drilling	San Xavier North, Arizona	(8)
Geologic mapping and leached capping study	Esperanza, Arizona	(9)
Sampling and geologic interpretation of old mineral prospect	Christmas, Arizona	(10)
Geologic interpretation based partly on magnetics, followed by wide-spaced offset drilling	Twin Buttes, Arizona	(11)
Geologic and leached capping interpretation of unusual outcrop and geochemical survey	Dos Pobres (P.D.), Safford, Arizona	(12)
Geologic and leached capping interpretation of old mineral prospect	Ithica Peak, Arizona	(13)
Geologic mapping and test drilling—old prospect evolved into orebody in part due to shifting economics	Sierrita, Arizona	(14)
Geologic and leached capping interpretation of old mineral prospect	East Helvetia (Rosemont), Arizona	(15)
Geologic reconnaissance program located small outcrop interpreted to be pyritic capping peripheral to orebody	Sacaton, Arizona	(16)
Old deposit which evolved into an orebody with geologic mapping, drilling and improvement in economics	Battle Mtn., Nevada	(17)
Geologic mapping and interpretation of structure and concentric zoning	Kalamazoo, Arizona	(18)
Geologic mapping and IP survey	Vekol, Arizona	(19)
Geologic interpretation of surface geology and re-interpretation of previous drilling	Copper Creek, Arizona	(20)
Leached capping and geologic interpretation	Caridad, Mexico	(21)
Geologic mapping and test drilling. Old prospect evolved into orebody	Copper Basin, Arizona	(22)
Geologic mapping and drilling done near fault segment orebody. Also IP survey	Lakeshore, Arizona	(23)
Geologic interpretation of peripheral outcrops followed by wide-space offset drilling	Poston Butte-Florence, Arizona	(24)
Geologic interpretation of vertical zoning followed by deep drilling	Red Mountain, Arizona	(25)
Geologic interpretation of previous drill data	Hillsborough, New Mexico	(26)

er than residual soils; and typically thick leached and oxidized zones which do not give an IP response. Both the IP and geochemical methods are best suited to a British Columbia environment of near-surface sulfides and shallow cover. As Southwest exploration progresses into deeper and deeper postmineral cover these methods will also tend to become less effective unless new and more reliable techniques can be developed.

The tabulation of discoveries indicates that seven of the last eleven deposits were essentially completely covered (one, Lakeshore, had 10 percent outcrop), and that since 1960, seven of the ten discoveries in Arizona have been completely covered. The percentage of covered discoveries is certain to increase in the future.

Reviewing some of the other factors on the tabulation we see that there were ten deposits discovered in the period 1943-1955, nine deposits discovered from 1955-1965, and seven deposits discovered after 1965. This suggests a progressive decrease in the success rate. It should be noted that many of the deposits have multiple discovery dates which reflect an earlier intersection of the mineralized body, and a later decision that it may represent a minable deposit—often by a different company. There seems to be no consistent variation in size of the deposits through the 33-year period, nor is there a noticeable change in the distance from a known porphyry. As mentioned, the amount of postmineral cover over discoveries has progressively increased through the period. Geochemical surveys appear to have been somewhat more useful than geophysical surveys, although geochemistry has never been the principal factor in a discovery as was the case for the Pima magnetometer survey. Geophysical surveys also have had some useful depth-of-cover and groundwater applications.

It's interesting to note that one orebody was found in an old company file cabinet, and one deposit was found by a re-interpretation of old drill data. Zoning interpretations and offset drilling are mentioned more frequently toward the bottom of the table as no more ore outcrops remain to be tested. Also almost every deposit was specifically discovered by a drill hole—whether drilled for the right reason or the wrong reason. There would have been very few discoveries without the drill rig, and the programs which never progressed from the "think stage" to the "drilling stage" were invariably doomed to failure.

It would perhaps be useful to select three deposits representative of the three decades covered by the tabulation and describe each to illustrate changes in settings and in successful exploration techniques over this period.

The first example is King Peak—Metcalf, immediately east of the Morenci—Clay orebody. This exploration target was identified in a careful and accurately interpreted leached capping study completed in 1952, and the first exploration hole intersected ore. The pre-discovery drilling cost of the project was very low. Tyrone would be a similar example, but no targets of this type now remain untested in the United States, although there may still be a few in Latin America and Iran and Pakistan.

The second example is the Sacaton deposit found near Casa Grande, Arizona in 1961. This discovery was one of several Asarco finds which resulted from a comprehensive district-wide program of geologic mapping in southern Arizona of features related to porphyry copper mineralization. This regional work tended to bridge the gap between theoretical and applied geology, particularly in the areas of stratigraphic and structural interpretation. Several holes at Sacaton were initially drilled as offsets around a small outcrop identified as being pyritic, but probably porphyry-copper-related, leached capping, before ore was intersected. Many additional drill holes were required before a viable orebody was confirmed, and the overall ratio of development drill footage to tons of ore developed was also high.

The third example is the Red Mountain deposit near Patagonia, Arizona, discovered in 1970, and described in a recent Economic Geology paper by Russ Corn. This is the deepest porphyry which has so far been found. It is in an area of premineral outcrop where shallow, sub-commercial mineral deposits have been known for many years. Discovery of the deep deposit resulted from persistent and thoughtful exploration to progressively deeper depths over a period of 12 years. The key to the discovery was vertical hydrothermal zoning theory. The pre-discovery driling expense was very large, and post-discovery drilling and development expense will be very large.

The conclusion from this review must be that deposits are becoming harder and more expensive to find. Most of our exploration tools become less effective with increase in thickness of postmineral cover. Recent shifts in copper economics have been a further obstacle; however, copper exploration, like the copper market, has always been a cyclic field, and many additional deposits remain under the Tertiary gravel and volcanics which will probably be discovered in the next 30-year period.

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May 15,1974

J. H. C.

MAY 20 1974

American Smelting and Refining Co.
Exploration Department
Box 5747,Tucson,Ariz.,85703.

Gentlemen:

I am sorry that there has been a misunderstanding as to the propriety of the location of claims that later became your Mission Mine. There was no question as to the legality.

I made several examinations of the Pima Mine, first for United Geophysical and then for Pima Mining Co. Most of my association was with Drex Spaulding and Mr. Pielemier.On one of my earliest trips I told Spaulding that there was a chance of finding a large low grade deposit in addition to the richer ore that was being developed underground. I recommended the location of additional claims and development, mmostly drilling, to prove this theory.The memorandum of November 30th,1953, copy of which you sent me, shows that Pima was acting on this recommendation on that date; that Asarco geologists were told of the results of the work; and that Mr.Spielmeier asked you to get in touch with Spaulding before locating additional claims.

Both Asarco and Anaconda geologists were at the Pime during one or more of my visits. Neither they nor Drex Spaulding told methat there had been any agreement about locating ground. After Asarco had found ore in ground near that located by Pima I remember that Spaulding was much upset.

In my book "Copper" as quoted by you,I stated that when a company gives another results of exploration, there is a chance that the information will result in injury to the first company.In spite of this I was, and am, sure that free interchange is the best policy.

Formal agreements in such cases are seldom practicable, and might not be legal.Everyone must rely on good will, and misunderstandings are likely. This was apparently true in the Mission-Pima case. I am sorry that Drex is not alive to clear up the affair.

Yours very truly

Ira B Joralemon

Ira B.Joralemon

AMERICAN SMELTING AND REFINING COMPANY
EXPLORATION DEPARTMENT
P.O. BOX 5747, TUCSON, ARIZONA 85703

J. H. COURTRIGHT
CHIEF GEOLOGIST

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

May 6, 1974

Mr. Ira B. Joralemon
315 Montgomery
San Francisco, California 94104

Dear Sir:

Reference is made to your recently published book entitled "Copper" wherein you comment on acquisition of the Mission property. Excerpts follow (Pages 326, 327):

> "A far more serious loss came from the generosity of Pima in letting engineers of other companies visit their property and even see the drill cores. As the value of the low-grade disseminated deposit east of the richer ore became evident, Pima started to locate a large group of claims out in the desert. But American Smelting and Refining Company engineers had seen the Pima drill cores, and with this knowledge they located for Asarco a great area farther northeast. Much of the low-grade ore extended into the Asarco claims, which were called the Mission Mine."

> "This loss to Pima of one of the great copper mines makes one wonder whether generosity in welcoming visitors is worthwhile. Sixty years ago, due partly to apex lawsuits, all information was carefully guarded. Dr. James Douglas and Dr. Louis D. Ricketts were largely responsible for a more liberal policy, although they realized that now and then someone would take an unfair advantage of the free information. But they were sure that in the long run an interchange of knowledge would benefit everyone, and in most cases they were right. Pima suffered by the policy, but if Pima had not known of the success in mining very low-grade ores at Morenci, it might not have acquired any part of the Twin Buttes District. As in nearly all our endeavors, we must weigh a gain against a possible loss."

Very briefly the facts are:

Following underground development of the Pima deposit, various companies (Anaconda, ASARCO, Eagle Picher, Cerro, Phelps Dodge, Newmont) <u>were invited</u> and most did examine the workings and drill cores with the

understanding that offers to purchase or option would be entertained. Thus, no "generosity" was involved in "allowing" other companies to examine the prospect.

Subsequently, our management advised United Geophysical that ASARCO planned to acquire ground in the vicinity, but would exclude any areas that United Geophysical wished to designate. As evident in the first paragraph of a file memorandum dated 11-30-53 (copy attached) the only area designated was that southeast of Helmet Peak. Shortly thereafter (early December, 1953), we (Richard and Courtright) arranged a meeting with Drex Spaulding, then Pima manager, in his office and informed him personally of our intention to stake claims, but not over any ground that he might select for staking on behalf of his company. He selected an area southeast of Red Hill, and we proceeded to stake elsewhere.

We became aware much later that the fact of our conversation with Spaulding giving him first choice on any of the open ground was never reported by him to his superiors in Los Angeles. Nor, did he ever admit it to any of his local staff.

Furthermore, it was not until after ASARCO had pretty well drilled out the low-grade, large tonnage Mission deposit that Pima began to realize they had a similar very large potential in their own ground. In other words, at the time they did not need any more ground than they already had for what they thought was a small ore body.

Nevertheless, contrary to your statements (quoted above), they (United Geophysical, or Pima Mining Company) were given far more than fair treatment.

Yours very truly,

J. H. Courtright

J. H. Courtright
Then, Assistant Chief Geologist,
Southwestern Department,
ASARCO
Now, Chief Geologist,
ASARCO

Kenyon Richard

Kenyon Richard
Then, Chief Geologist,
Southwestern Department,
ASARCO
Now, Consultant--
Mining Geology

JHC:KR:vmh
Enc. 1
cc: All W/Enc.
J.J. Collins: Exploration Manager, ASARCO
T.A. Snedden: Then, Manager
Southwestern Mining Dept., ASARCO
Now, Vice President,
Mining Dept., ASARCO

Ken and Harold:

Enclosed are copies of various letters dealing with Mission. In my letter to Ed Tittmann, transmitting a copy of my letter to Darwin, I stated that I shouldn't be messing into the thing now that I had retired, but that I had gotten so damned mad at the manner in which the geophysicists had filched credit from you two that I finally decided to get something in the files. I told him that I didn't expect to accomplish any more than that.

Anyway, we have something on the New York file, and you can put the ones I am sending you in the Tucson file.

Was quite surprised to learn that Ken Wilson had resigned and has started a consulting office in San Francisco, and I really wish him luck. He told me of the deposit somewhere up north that you are drilling or preparing to drill and which, according to Ken, falls "right in one of my northeast zones". Wish you would give me the exact location so that I can spot it on my base map. Can then advise you whether or not it is worth fooling with.

Sincerely

Walt

[illegible] are fair game

January 14, 1961

AIR MAIL

Mr. D. J. Pope
American Smelting & Refining Co.
120 Broadway
New York, N. Y.

Dear Darwin:

I appreciated your letter, and the manner in which you accepted mine. I debated quite a long time before I decided to write you for to me there seems nothing more out of line, and in poorer taste, than for someone who has been completely severed from the organization's activities to attempt to criticise current events. But this case struck me as being somewhat different.

But now that I have gotten the matter off my chest, and my opinions in the file, I'm quite willing to drop the whole subject.

In my letter I disregarded the substantial contributions made by others in the Mission project, and there were quite a number, as you state. My particular, and limited, objective was to get into the file the history of the start of the project in order to refute the claims that its discovery resulted largely from the scientific application of geophysics.

As for my part in the matter, all I can lay claim to is that I sent Ken and Harold to Tucson and thereafter merely transmitted their recommendations to New York, and in the case of Mission without much optimism.

I am sending copies of my letter of January 4, your reply, Ed's letter of January 12, and of this letter, to Ken and Harold.

Frank Frost and Ken Wilson called on us yesterday. I was quite surprised to learn that Ken resigned and has opened a consulting office in San Francisco.

Our best regards to both you and Mary.

Sincerely

cc: E. McL. Tittmann
Kenyon Richard, with encls.
Harold Courtright " "

W. R. Landwehr

Copy of Ed Tittmann's letter of January 12, 1961 to W.R.L.

Dear Walt:

Thanks for sending me a copy of your letter to Darwin regarding the initiation of the Mission project. I also saw Darwin's reply and must say that, in view of what happened since the matter of credit was first publicised, I do not think it is necessary to do anything further. As you know, Hart has left and I do not think there is anyone in the company that does not hold Ken Richard and Harold Courtright in the highest regard not only for the work they did at Mission, but at Toquepala and many other prospects which, while they did not prove to be commercial ore, high-lighted the professional competence of these two men.

I will put your letter in the office files here.

****

Sincerely

E. McL. T.

Copy of D. J.Pope's letter of January 10. 1961 to W.R.L.

Dear Walt:

It was very nice to hear from you and I appreciate the effort which you have taken in writing to me so completely about the history of the discovery of the Mission Unit ore body. I hope that it mines out sufficiently well and that the copper price holds up well enough so that all of the argument about the credit for the discovery will prove to be worth-while. To go back a bit in the history of this, I think the argument started when you wrote and congratulated Messers. Richard and Courtright on their efforts, which I felt at the time was entirely in line and which was not intended to detract from the efforts of anyone else.

To have a successful organization, we must consider the successes or failures of our ventures to be the result of a joint team effort. I have discussed this fully in the past with both Kenyon Richard and Harold Courtright and I am sure that they know and fully realize that in the minds of the rest of us in the company their part of the effort was fully appreciated and that all of us realized that a great deal of credit is due to their initiating this particular project. Aside from that, as far as I am concerned, Walt, I think that you deserve a great deal of credit in the success of the copper exploration in the Southwest because you originally recommended sending Ken Richard in there in the first place, and persisted over considerable opposition in having that recommendation accepted. Along with this, Bud Richard should always be mentioned because he was always an optimist and pushed some of these exploration ventures, plus the support, of course, of the other Company officials clear to the top.

So think it would do more harm than good to the Company and to their future exploration efforts to try to correct, publicly, any possible wrong impression in certain quarters outside the Company because of something published in some magazines which are often not very accurate anyway.

Regardless of all the above, your complete story and analysis is of great interest within the Company. I have discussed it with Mr. Tittmann and I will also show it to Messers. Brown and Pollock. Besides this, I will sound out Ken Richard the next time I see him and make sure that there is no feeling on his part that any one of us now with the Company does not recognize the worth of his work, both with regard to Mission and other ventures. In my own mind I am sure that he understands the situation as I have repeatedly complimented both him and Harold on the excellent work that they have done, including the very good report that Harold wrote on the Trench mine, which enabled us to operate there for several years at a profit, when without his direction we would have given up on trying to find more of the small scattered ore bodies.

If you feel that you wish to write to Ken passing any of this along to him, please feel entirely free to do so, but I do not think we should enter into any future public argument about this matter. I will appreciate your letting me know whether or not you agree and are willing now to let it drop.

Sincerely

D. J. P.

cc: Ed Tittmann-Personal

Menlo Park, Calif.
January 4, 1961

Mr. D. J. Pope
American Smelting & Refining Co.
120 Broadway
New York, N. Y.

Dear Darwin:

The Mission ore body is the major new copper discovery made in the United States in late years, so naturally has aroused a great deal of interest in the mining profession. Not only is it of interest because of its commercial importance but, as it is located in a gravel-covered plain in which there are no outcrops, and within sight of Tucson which has been the hub of mining prospecting and scientifically directed exploration since the arrival of the white man in the area, the manner of its discovery has stirred up a great deal of general curiosity, and particularly professional interest on the part of geologists and geophysicists.

As you well know, the question of credit for the initiation of the project and the subsequent discovery of the ore body, has been the subject of considerable comment and discussion within the company for some time, the problem mainly resolving itself into the question of the amount of credit due the geological department of the Southwest, and the geophysical department. You mentioned the matter when you called upon us here in Menlo Park more than a year ago, and I had previously discussed it with Mac when I last saw him, in Salt Lake shortly before I retired. To both of you I expressed the opinion that the geophysicists were claiming, and had gotten, far more credit than was due them.

This, perhaps, would not be too serious were it confined within the company where most of those concerned have at least a fair idea of the facts. But since coming to the Bay area and mingling with more of the general profession, I have been surprised to learn that some, at least, have gotten the impression that the discovery was due almost solely to the successful application of geophysical methods, and that the geologists played only a minor role in the matter. I don't know how widespread this misconception is, but believe it to be somewhat general.

This misunderstanding undoubtedly is largely due to published statements, and in part to oral statements about which I have heard from reliable sources. All have been misleading because they did not clearly state the facts. In some cases the misstatements seem to have been deliberate, in others inadvertent.

I knew of this tendency to claim undeserved credit from its inception but did nothing about it. But after coming here and becoming aware of the erroneous impression gotten by some in the profession, and learning for the the first time of the published statements, I decided to review pertinent letters, reports, and maps and write a summary to you in order to get something in the files, and myself on record. As Ed Tittmann is as vitally inter-

ested in Mission as anyone, and hence would be interested in the manner of its discovery, I am sending him a copy.

I want to emphasize that this is my idea. I know that the geologists of the Southwest have been somewhat amused, to put it mildly, over the matter of credit for some time but none have had anything to do with my decision to write this letter, nor its composition other than to furnish me, at my request, some information. Most of the information that I have was brought with me from Salt Lake.

The first published article that came to my attention appeared in the January 1958 issue of Mining World. It states:

> "Geological Discovery of the Year, was the East Pima, Arizona project of American Smelting and Refining Company.... The ore body does not outcrop. Its discovery followed geologic projection of known ore bodies in the nearby Pima Mining Company and Banner Mining Company mines."

In the May 1958 issue of that publication there appears a letter written by Mr. Hart commenting on the foregoing article. The caption of the article in which Mr. Hart's letter appears is: "Pima is Geophysical". Then follows Mr. Hart's letter, from which I will quote.

> Dear Sir:
>
> This refers to your comments regarding the East Pima, Arizona project of the American Smelting and Refining Company. You credit this to be: The Geologic Discovery of the Year: but in the last sentence of the paragraph, you state:
>
> "Its discovery followed geologic projection of known ore bodies in the nearby Pima Mining Company and Banner Mining Company mines."
>
> Obviously, if this statement is correct, the East Pima development would not be a discovery at all, but is instead, only normal development along known ore extensions.
>
> The fact is that East Pima is a new discovery, which is the result of a well coordinated exploration program, to which valuable contributions have been made by our Geological and Geophysical Departments. The principal geological contribution was to select and recommend the area for careful investigation by our Geophysical Department. Information obtained in geophysical surveys pinpointed the important new discovery....
>
> Since our geologists and geophysists have done a commendable job on East Pima, it seems unfair to them to classify their accomplishments as routine "geologic projection of known ore bodies.
>
> L. H. Hart
> Chief Geologist

Then follows this statement by the editor: "Congatulations to ASARCO'S staff for making this "Geophysical Discovery of the Year."

It is obvious why the profession has gotten the impression that the discovery of Mission was largely the result of applied geophysics.

Mr. Hart was right in stating that the project was not based upon exploration in search of extensions of known ore bodies. However, his statement that "the principal geological contribution was to select and recommend the area for careful investigation by our Geophysical Department" was a gross misrepresentation of the facts. It implies that the decision on whether the ground would be judged sufficiently promising for exploration rested upon the results of the geophysical survey. And, secondly, it states that successfully applied geophysical methods pinpointed the ore body, which is a similar misrepresentation of the fact, as I shall show in paragraphs which follow.

In the first place Mr. Hart had nothing to do with the initiation of the project so could have no firsthand knowledge of the reasoning upon which the selection of the ground for acquisition and exploration was based. Certainly the geologists had no thought of selecting an area primarily for examination and judgement by the geophysical department. It was acquired and recommendations made for drilling without consideration being given to any results that a geophysical survey might disclose. In fact, after recommendations to acquire and drill the ground were made, Richard and Courtright in a letter asked for Mr. Lacy's comments on geophysical methods that might be applicable in exploration. In reply he stated that geophysical surveys were infeasible for he assumed that the United Geophysical Company had already surveyed the area and had found nothing of interest as far as replacement deposits similar to the Pima deposit were concerned, and he had no method that would detect disseminated deposits. But inspite of this the geologists proceeded with property acquisition and exploration. So there is no factual basis for Mr. Hart's statement that the principal contribution of the geologists was to select the ground for geophysical investigation.

In later paragraphs I will show precisely how the geophysicists, after they finally completed a survey, "pinpointed the important new discovery".

A third article, appearing in the August 1960 issue of Mining World, also implies that geophysics played the major role in the selection of the ground. It is entitled:"Fast Start at Mission: American Smelting Now Stripping 2,500,000 Tons a Month". In it is stated:

> "The most important new copper mine in the United States is rapidly being developed 20 miles south of Tucson, Arizona...Alluvium everywhere overlies all bedrock formations. However, earlier geophysical exploration had detected a high anomaly in the area."

To the knowledge of the geologists no geophysical survey that had detected a promising high anomaly had been made prior to our acquisition of the ground. To confirm that this was also the case with the geophysicists I wrote Mr. Lacy last October 17, quoted from the article in Mining World, and asked whether he knew of such a survey. To date I have not received an answer so I assume that he does not.

So again the mining profession was misinformed, in a technical article, and credit given to the geophysicists for Mission.

George Argall, Jr. editor of Mining World, informed me that the article was approved in Tucson by Mr. Hall, and in New York by you.

The remainder of this letter contains more of the details of the acquisition and discovery of Mission, and the relative roles played by the geologists and geophysicists in the matter.

It should be kept in mind that two types of deposits can normally be expected in the district. One is the bedded replacement type in sedimentary rocks. The Pima deposit is a replacement of a limestone bed in the arkose series. Because of its high content of magnetite it was particularly susceptible of detection by the magnetic method. The other type, the disseminated mineralization of Mission.

The idea that a deposit of disseminated mineralization might be present under the gravel covering east and north of the Pima ore body originated with Courtright who, after a preliminary reconnaissance of the district, wrote a memorandum to Mr. Sneddon on January 5, 1953 in which he called attention to the alteration and mineralization in Red Hill, which is located about half a mile southeast of Pima. In this memorandum he stated:

> "While the hill itself does not appear to hold potentialities, the surrounding gravel may conceal altered intrusive rocks and associated mineralization of possible commercial grade."

Thereafter he further studied the area, prepared a generalized geologic map, and summarized his findings and conclusions in a memorandum to Mr. Sneddon of February 27, 1953. He stated:

> "Deposits comparable to the San Xavier and Pima are not sufficiently large to justify any particularly big risk in exploration, however, those, in combination with a larger objective --- such as a porphyry copper deposit --- offer more favorable odds for an exploration gamble."

As a first step he suggested staking a central block of 90 claims.

Again, in a geological report by Courtright and Hardie dated October 12, 1953 it is stated:

> "If these speculative features are combined with the the two facts, (1) that the Pima ore body is the best and biggest of its type in the district, and (2) the "Red Hill" is the strongest alteration zone, the inference is made that there is a fair chance for the occurance of a gravel-covered porphyry copper ore body. We have recognized no structure or other geological evidence suggesting the position of such a deposit, other than that it would most likely be easterly or northerly from Red Hill." (It actually is northerly and northeasterly.)

Ken Richard in transmitting Courtright's report, in a letter dated October 12 agreed, stating:

> "Taking all factors into account, the exploration gamble is an attractive one, and the property should be acquired with the expectation of following it up with drilling."

The property to which he referred was that of the Lima Mining Company, but he also recommended the acquisition of the Chilson and Nauman groups, and the location of claims in the open area north and east of Lima's ground, which we did immediately thereafter.

The first mention of the use of geophysics in connection with the project was in a letter by Richard and Courtright dated November 19, 1953 in which Mr. Lacy was asked for comments concerning geophysical methods that might be applicable. Mr. Lacy answered the request in his comprehensive letter to me of November 25, stating:

> "It is felt that the United Geophysical Company covered the area of interest on open land thoroughly with the sulfide replacement type deposit especially in mind. They then staked all of the area on which anomalies possibly indicative of this type of deposit were found. We may then assume that it would be infeasible to duplicate this work."

He then commented at considerable length on whether or not United Geophysical had in mind a disseminated type of deposit when interpreting the results of its surveys and concluded that it did. He then stated that if United Geophysical did not object to our staking ground (which it didn't):

> "we arrive at a conclusion similar to those for sulfide replacement deposits in that it would be infeasible for us to duplicate United Geophysical Company's geophysical surveys."

And under "Conclusions" in the same letter he states:

> "The conclusions to be drawn from the above discussion is that there is no need for us to conduct geophysical surveys in the area covered by the United Geophysical surveys."

The foregoing, then, clearly refutes the implication in Mr. Hart's letter to the Mining World that the geologists were merely looking for something for the geophysicists to survey and judge. Had that been the case we would not have acquired the ground but would have dropped the project upon receipt of Mr. Lacy's letter.

It is equally as interesting and revealing to investigate the manner in which, as stated by Mr. Hart, the geophysicists "pinpointed the important new discovery".

A brief description of the physical structure of the Mission ore body, as determined by drilling, will assist in evaluating the results of the electromagnetic survey that were used in "pinpointing" the ore body.

The Mission body of mineralization consists of three parts, an upper blanket of oxidation and leaching, beneath which is a thin blanket of enriched sulfides, and below that the body of primary mineralization; all of which is characteristic of disseminated copper deposits. The contacts between the three units are roughly horizontal. The top of the blanket of secondary enrichment is remarkably uniform in elevation, varying not more than

50 feet throughout the area of the final pit. The depth below the surface of this blanket is also rather uniform within that area. According to Courtright, probably 95% of the copper occurs as discrete grains and small irregular masses. However, there are bodies of massive sulfides of appreciable size such as those along the East Fault.

During 1934 twelve scout holes were drilled, widely and randomly spaced. These were drilled to shallow depths in a search for for indications of a disseminated type of deposit. No mineralized porphyry was encountered, nor any substantial sulfide mineralization, but the results indicated the existence of a large area of alteration and weak mineralization in the arkosic sediments. These holes were east of the ore body.

Perhaps the discovery of the alteration and mineralization changed the opinion of the geophysicists as to the efficacy of geophysical methods in the problem, for electromagnetic and magnetic surveys were completed in the latter part of that year and recommendations for drilling made by Mr. Saegart to Mr. Lacy on December 30. In turn Mr. Lacy, on February 9, 1935, recommended to me a rather comprehensive drilling program to test the various anomalies determined by the surveys. It should be repeated that the methods used were, according to Mr. Lacy's prior statements, only capable of detecting replacement sulfide bodies of the Lima type.

The electromagnetic survey resulted in about 30 anomalies within the claim area, with the greatest concentration in what is roughly the western third of what is now the pit area. The anomalies were all linear, the majority trending northeasterly and easterly. Mr. Lacy considered them to be caused by possible sulfide replacement deposits, hence recommended rather closely-spaced profile drilling along north-south lines. He believed that the anomalies corresponded roughly with the apexes of the replacement bodies. Anomalies I and II were the initial targets.

Anomaly II was tested first, with four holes ranging in depth from 350 to 550 feet. No replacement deposit was found and, as the anomaly is considerably east of the ore body as we now know it, no encouraging mineralization.

Anomaly I, which was the stronger of the two, was next drilled. The objective again was a replacement deposit to which the anomaly was thought to conform. The objective of the initial series of holes of profile drilling, along profile 45 W, was, according to Mr. Lacy, "to determine the relation of possible mineralization to the positions of the conductor axes to check dips, and to obtain cross-sectional geologic data". If the presence of a replacement deposit were determined then other holes were to be drilled for "a rapid evaluation of strike extensions".

As he stated, Mr. Lacy's interpretation of the anomalies was that they were caused by possible linear replacement deposits similar to Lima, and his drilling recommendations all conformed to that interpretation. In the same letter he stated, relative to disseminated copper sulfide deposits:

"Since the magnetic method was proved inapplicable to this problem in the East Lima area, we have at present no geophysical method that can aid the geologist."

The first hole, No. 16, encountered the first sulfides of commercial grade, as did the other three holes drilled along this profile. However, the positions of the intercepts, and the results of all subsequent drilling in the ore body, proved that the mineralization was not that of a linear replacement deposit with steep dip such as Lima, but was the secondarily enriched blanket-like top of the disseminated deposit. This is shown by the fact that the top of the mineralization in the four holes of the initial series, covering a 300-foot segment of the profile, was at the same elevation in all four holes.

After determining that the holes had encountered a more-or-less horizontal blanket of disseminated mineralization I purposely asked Mr. Lacy whether or not he had a method that could detect such an ore body. He stated that he did not.

There is additional evidence to take into account in evaluating the significance of the anomalies, which were the basis of the geophysicists' claim to a discovery, as indicators of the Mission ore body.

First, in the profile of the discovery Anomaly I, 45 N, in seven holes covering a section length of 1250 feet, the same type of mineralization was encountered at elevations that had an overall variation of not more than 25 feet. There were no anomalies in the vicinity of two of these holes, yet the same type of mineralization was encountered.

Second, is the erratic distribution of the 30 anomalies. The majority are located in roughly the western third of the pit area even though the mineralization is more-or-less continuous throughout that area, and certainly is as abundant in the eastern two-thirds. Some of the anomalies are outside the limits of the ore body.

Third, there are no anomalies corresponding to the abundant sulfides that occur along the East Fault. This is a vertical fault breccia that terminates the ore body on the east. Workings from the East Lima shaft, according to Ken Richard, encountered massive sulfides lying along the fault that in places are 15 to 50 feet in horizontal thickness. The depth of the sulfides is slightly less than the sulfides in the discovery hole. It is precisely the linear sulfide type of deposit that Mr. Lacy envisioned as causing the anomalies, yet there is no corresponding anomaly even though the entire area of the massive sulfides was covered by the surveys.

As linear sulfide replacement bodies correlating with the anomalies were not encountered as expected, other explanations of the anomalies, which attempt to associate them with the type of mineralization that was discovered, have been advanced. These to me seem involved, vague, elusive, and as being advanced in the hope of salvaging whatever remains possible of the basis for the claim of discovery. They strike me as being the product of sub-

jective thinking rather than objective reasoning.

The geophysicists deserve the full amount of credit that is due them for the depth to which the discovery hole was drilled. Had we not followed their recommendations in drilling for the anomaly we might not have drilled to the depth of the ore body, but it is not likely that this would have been the case for we knew of the long intercepts of disseminated mineralization in arkose That United Geophysics had gotten in the hanging-wall of the Pima ore body, and we had encountered leached capping in arkose in several of the shallow holes drilled prior to the discovery hole. But this really beside the point, for the question that I am discussing is the amount of credit due the geophysicists in the discovery as a result of the scientific application of geophysical methods.

Evaluating, objectively, the results of the geophysical surveys, and the results of all subsequent drilling, the only logical conclusion that can be reached is that the encountering of mineralization in the discovery hole was not due to the successful scientific application of geophysical methods, but rather was purely accidental. Had the hole been drilled anywhere within the limits of the proposed pit, without regards to the positions of the anomalies, a similar discovery would have been made. Yet this is the sole basis for all the credit of discovery claimed by the geophysical department, and reveals the manner in which "the geophical surveys pinpointed the important new discovery" as claimed by Mr. Hart in his published letter.

Because of the importance of Mission the mining profession should be given a true perspective of the manner of its discovery, and the body of geophysical scientists should be set straight. But above all the full recognition of the credit due the geologists of the Southwest should be given not only within the company but also within the general profession.

As the profession has been misinformed through published statements, the only proper way in which to correct the situation is by means of a published comprehensive factual article prepared by a competent and disinterested person who has access to all pertinent data.

Yours very truly,

W. R. Landwehr

cc: E. McEl. Tittmann

J. H. COURTRIGHT

C
O
P
Y

WESTERN MINING DEPARTMENT
Salt Lake City, Utah

January 11, 1954

AIR MAIL

Mr. C. P. Pollock, Exploration Manager
American Smelting and Refining Company
120 Broadway
New York 5, N. Y.

ARIZONA, PIMA COUNTY
Pima District
PORPHYRY COPPER EXPLORATION

Dear Sir:

As you know, we have acquired a considerable amount of ground easterly from the Pima mine, by lease and option and by claim location. The enclosed map shows the Chilson ground, upon which we have an acceptable lease and option; the Nauman ground, upon which we have a lease and option the terms of which may not be acceptable; and the claims which we located. The map also shows the ground owned by the Pima Mining Company and the United Geophysical Company.

The acquisition of this ground is based upon the possibility that it may contain a copper deposit of the disseminated type. As the drilling campaign that will be necessary before we can determine whether or not such a deposit exists will cost a considerable amount, I think it is well to summarize the factual basis upon which the project rests.

The possibility that a commercial deposit of disseminated mineralization could exist in the gravel-covered area was first called to our attention by Mr. Courtright in his memorandum to Mr. Snedden of February 27, 1953. His belief that disseminated deposits might exist was based upon the presence of mineralization of that type in arkose outcropping on Pima ground easterly and southeasterly from the Pima ore body. Referring to the existence of deposits, both of the replacement and disseminated types, in the area, he states, "The chances of finding either type of deposit are, however, quite long, being based on geologic permissibility rather than probability." This statement was made before we had access to the records of the Pima Mining Company.

Later, when the Pima Records were made available to us, it was learned that disseminated mineralization in arkose was encountered in several of their surface diamond drill holes in the hanging wall of the Pima ore body and to the east of it. Based upon this added information, Mr. Courtright stated in his report of October 12, 1953 on the Pima mine, "The inference is made that there is a fair chance for the occurrence of a gravel-covered porphyry copper ore body," but pointed out that "we have recognized no structure or other geological evidence suggesting the position of such a deposit other than it would most likely be easterly or northeasterly from Red Hill."

Mr. Kenyon Richard, in his letter of October 12 transmitting Mr. Courtright's

Mr. C. P. Pollock

report, in commenting on the possibilities for disseminated deposits, states, "Taking all factors into account, the exploration gamble is an attractive one, and the property should be acquired with the expectation of following up with drilling." The property referred to is that of Pima Mining Company, but he also recommended acquisition of the Chilson and Nauman ground, and the location of the claims that have since been located by Asarco.

From the foregoing, it can be seen that this proposal is based upon rather definite factual evidence that indicates a possible porphyry copper environment; in other words, there can be a commercial deposit of that type in the gravel-covered area. However, as stated by Courtright, there is no direct evidence of its probable position if it actually exists. We all realize that it is a long-shot gamble, but as such it is worthwhile. However, if we should decide to do some exploratory drilling it is my opinion that we should attempt to acquire more ground to the east.

This project is separate from that of the Pima mine, and our decision should not be influenced by the results of our negotiations for that property. However, no drilling should be started prior to the conclusion of negotiations.

Very truly yours,

WRL:si

/s/ W. R. Landwehr

enc. Map #1185
K. E. Richard's memo Jan. 4, 1954 to T. A. Snedden

cc: D.J. Pope w/map
K.E.Richard w/out map

Copied at Tucson January 23, 1954, for Mr. Courtright.

C
O
P
Y

November 25, 1953

MEMORANDUM TO: Mr. W. R. Landwehr

ARIZONA, PIMA COUNTY
PIMA DISTRICT
GEOPHYSICS

INTRODUCTION

Messrs. K. E. Richard and J. H. Courtright, in their letter of November 19 re the Pima mine, requested my comments concerning geophysical methods that might be applicable. This is a two-phase geophysical problem with respect to two types of deposits, sulphide replacement and porphyry copper. These have been discussed in numerous letters and memoranda in the past, mainly in the following:

Date	From	To	Copies To	Subject
January 13, 1953	R. J. Lacy	D. J. Pope	C.P.P. L.H.H. E.McL.T. W.R.L. F.V.R. T.A.S. R.F.W. L.K.W.	United Geophysical Company's exploration methods in Pima district
June 17, 1953	R. J. Lacy	C.P.Pollock	L.H.H. D.J.P. F.V.R. W.R.L. K.W. T.A.S. M.W.C. K.E.R. L.K.W. J.H.C.	Example completion of Reconnaissance Summary form
June 26, 1953	C.K. Moss	W.R.Landwehr	K.E.R. L.K.W.	Magnetometer test survey for porphyry copper deposits in Pima district.

It is felt that the United Geophysical Company covered the areas of interest on open land thoroughly with the sulphide replacement type of deposit especially in mind. They then staked all of the area on which anomalies possibly indicative of this type of deposit were found. We may then assume that it would be infeasible to duplicate this work.

The United Geophysical Company initially may not have been aware of the porphyry copper possibilities, and so interpreted any broad "basin" of magnetic contours as indicating a topographic low in the basement complex of granite-sedimentary contact. This aspect presents interesting possibilities which are discussed below;

Porphyry Copper Deposits

Mr. C. K. Moss' magnetometer test surveys were conducted mainly south of the presently recommended area of interest. Although the tests were not considered favorable, they were not conclusive for the following reasons:

1. The granite in the granite-sedimentary outcrop area tested in the western part of the district may not be representative of the possible monzonite intrusion postulated in the eastern part of the district.

2. The few profiles run in the southeast area are not considered an adequate test, especially since we do not know whether porphyry copper alteration exists there. There is a magnetic low at the north end of profile 3, where an outcrop of arkose with disseminated sulphides was observed on Red Hill. This may be interpreted either as the fringe of a hydrothermal alteration zone in which accessory magnetite was converted to non-magnetic minerals, or merely the lack of alluvium containing concentrations of magnetite.

3. The erratic readings obtained in the alluvium covered areas undoubtedly result from erratic concentrations of magnetite in the alluvium within a few tens of feet depth. This can be a confusing factor in the interpretation.

The considerations, in relation to the United Geophysical Company and their surveys, are as follows:

1. Their magnetic contour maps may have indicated a broad basin-like anomaly, but

   a. they were not aware of porphyry copper possibilities and interpreted a "topographic low" of the basement complex (granite-sedimentary contact),

   b. they were aware of such possibilities and gravimetric and/or seismic data possibly confirmed the postulation of a "topographic depression" of the granite-sedimentary contact.

   c. or they simply were not prepared as a matter of policy to conduct exploration and development work for porphyry copper deposits.

2. There is no broad basin-like anomaly indicated on their magnetic contour maps, because

   a. the granite-sedimentary contact dips steeply to the east,

   b. the accessory magnetite content of the fresh granite may be unusually low so that there would be no appreciable magnetic susceptibility contrast with hydrothermally altered zones.

   c. or a porphyry copper deposit does not exist in the area surveyed.

If we were able to obtain and study United Geophysical Company's geophysical data and maps, this would be the ideal situation in order to determine which of the above listed conditions, 1 or 2, obtains. This may be possible, if our negotiations for the Pima mine are successfully concluded. However, I would assume that, even though they may not have been aware of porphyry copper

possibilities initially, they are now cognizant of such possibilities. In this case, it is more than likely that separate negotiations would be necessary with regard to the Pima mine property on the one hand and both the United Geophysical property in the recommended area of interest and corresponding geophysical data on the other hand. This may apply if either condition 1a initially obtained or 1c obtains. In the latter case, they would be interested in the sale value of any geophysical data favoring existence of a porphyry copper deposit. Their reaction to our proposal to stake ground in the district, and their activities in staking more property, will be revealing. If they stake more ground, we might assume that their geophysical data are favorable to the postulation of the existence of a porphyry copper deposit in the new areas staked.

If either of the conditions 1b or 2 obtains, they would not object to our staking ground, they would not conduct such activities themselves, and they would not speculate on the sale value of their geophysical data. In that case, we arrive at conclusions similar to those for sulphide replacement deposits in that it would be infeasible for us to duplicate United Geophysical Company's geophysical surveys. One possibility still exists, however. That is the postulation 2b that there may not be a sufficiently high concentration of accessory magnetite in the granite to afford a magnetic susceptibility contrast with hydrothermally altered zones. This places the burden entirely on the sparse geological indications, and favors staking the recommended area and drilling the reconnaissance holes for porphyry copper exploration.

Conclusions

The conclusion to be drawn from the above discussions is that there is no need for us to conduct geophysical surveys in the area covered by the United Geophysical Company surveys. Their staking activities will reveal whether or not their re-interpretation of the geophysical data favors the postulation of a porphyry copper type of deposit. If they do acquire more property now, we may judge from the size and locations of such land acquisitions whether or not they are interested in porphyry copper exploration or the sale value of such geophysical data and newly acquired properties. We then have no alternative but to negotiate separately for such data and property if we are interested in dealing on this basis. This is so because the inference that the geophysical data confirms a reasonably shallow granite-sedimentary contact and sufficient accessory magnetite in fresh granite to allow for interpretable variations would be strengthened.

If the United Geophysical Company does not object to our staking the recommended area and does not acquire new property themselves, we may reasonably assume the geophysical data are not favorable. We may then postulate the one chance if geophysical data are not favorable. That is that an unusually low accessory magnetite content in the fresh granite does not afford sufficient contrast of magnetic susceptibility with hydrothermally altered zones. The recommended claim staking and reconnaissance drilling on the basis of the geological indications then may be considered.

/s/ R. J. LACY

RJL:si
cc: CPPollock
FVRichard
TASnedden
KERichard
JHCourtright

November 6, 1953

MEMORANDUM TO: Mr. F. V. Richard

ARIZONA, PIMA COUNTY
PIMA DISTRICT
PIMA MINE

I have studied the geological report of October 12, 1953 on the Pima mine by Courtright and Hardie, and have the following comments:

The report is well prepared and it is evident that it is the result of careful assembling and analyzing all pertinent data.

The estimate of measured and indicated ore is based upon good geological and engineering practices. The results of our spot-check of a number of ore blocks was very close to the tonnages used in the report. The method used in delimiting the various blocks introduces a factor of safety, but it is not deliberately unreasonable.

We similarly checked the average grade of a number of ore blocks, and in all cases our result was higher than that of the report, the difference being due no doubt to less knowledge of details on our part.

The estimate of inferred ore down to the 800 level also seems reasonable in view of the diminution in the grade of the mineralization between the 500 and 600 levels between coordinates 4600 E. and 4800 E.

As brought out in the report, the possibilities for additional ore of the replacement type are in down-dip extensions of the ore zone as presently developed, and in the easterly extension of the zone. There is also an indication that another mineralized zone may exist a short distance in the footwall of the Pima zone.

Mineralization of the Pima type, although often erratic in the distribution of the valuable content, should persist to a considerable depth. The Pima mineralization probably extends for a considerable depth below the elevation of the 800 level unless an unfavorable structure exists such as the granite in the San Xavier mine.

The eastward extent of the mineralized zone has not been determined. Undoubtedly the eastern limit of Pima's surface drilling marks the limit of the geophysical anomaly that resulted in the discovery of the ore body, but, for reasons given on page 15 of the report, this may not necessarily mark the limits of mineralization. From the evidence on hand, I am of the opinion that chances for additional appreciable amounts of ore to the east are good.

There is a possibility of another mineralized bed a short distance in the footwall of the Pima bed.

As emphasized in the report, and also by Mr. Richard in his covering letter, the Pima body may be peripheral to commercial porphyry-type copper mineralization in monzonite. The positive indications are sufficient to make this an attractive exploration possibility and one that should be taken into consideration in evaluating the Pima mine. It should be considered separately even though we do not acquire that property.

We should make every reasonable effort to acquire the Pima property.

ORIGINAL SIGNED BY
W. R. LANDWEHR

W. R. LANDWEHR

WRL:si
cc:K.E.Richard

EXERPT------from Geological Report dated October 12, 1953, entitled:

PIMA MINE
Pima Mining District
Pima County, Arizona---------by J. H. Courtright and
B. S. Hardie

Under section EXPLORATION POSSIBILITIES, pages 15 and 16

"Aside from possible extensions of the Pima ore zone discussed above, the widespread alteration and disseminated sulphide mineralization in the arkosic sandstone to the east and southeast are regarded as probable associates of a nearby igneous intrusive mass and/or breccia pipes. Relatively small patches of the same type alteration occur two miles southwest near the New Olivette and Helmet Peak mines (in arkose and volcanics) and are localized near small breccia pipes containing pyritic mineralization. Since no appreciable alteration is found within or along the fringes of the main granite mass on the west, it is considered likely that the alteration in the Pima area is related to a later Laramide intrusive such as the monzonite (or diorite) which occurs about 9 miles south of the Pima mine in the Esperanza area. Here, an altered zone contains a small porphyry copper prospect."

. . . .

"If these speculative features are combined with the two facts, (1) that the Pima ore body is the best and biggest of its type in the district, and (2) the "Red Hill" is the strongest alteration zone, the inference is made that there is a fair chance for the occurrence of a gravel-covered porphyry copper ore body. We have recognized no structure or other geological evidence suggesting the position of such a deposit, other than that it would most likely be easterly or northerly from Red Hill."

EXERPT FROM: Memorandum to Mr. W. R. Landwehr dated June 26, 1953, from Mr. C. K. Moss

Under Conclusions

"From the results of the brief magnetometer work, it seems that any information which would be gained by more detailed work would be too weakly diagnostic in itself to justify the cost of obtaining the information. It does not seem that magnetic information could give conclusive enough results to initiate a drilling program at Pima; however, magnetic work might be helpful in tracing alteration, if drilling were begun on the basis of more positive indications of a different nature and alteration were found in granite."

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

February 27, 1953

PIMA MINING DISTRICT
PIMA COUNTY, ARIZ.
(Area East of San Xavier)

Memorandum to Mr. T. A. Snedden

INTRODUCTION

In a recent memo (Jan. 5th) concerning the Pima Mining Company's copper deposit mention was made of pyritic alteration observed in a small hill of arkosic sandstone outcropping in the gravels one-half mile southeast of the Alpha Shaft.

Some further study of the area has been made and a generalized geologic map prepared, showing the principal elements of structure and mineralization. The following contains a brief review of features to be considered in attempting evaluation of exploration possibilities beneath the gravel cover.

GEOLOGY

The district is situated about 20 miles south of Tucson in an area of low relief broken by a few small knobs of more resistant (chiefly limestones) sedimentary rocks rising abruptly from the alluvial slopes on the west side of the Santa Cruz Valley.

The principal rock units are:

Gravels	- Recent	(Post-mineral)
Volcanics (Chiefly flows)	- Tertiary (?)	(Pre-mineral)
Shales, Arkosic sandstones	- Cretaceous	(ditto)
Limestone and quartzite	- Paleozoic	(ditto)
Granite - intrusive	- Laramide	(ditto)

A complex structural history is evidenced by the random arrangement of certain recognizable rock units. The predominating trend of the major faults ---Mineral Hill, San Xavier and South Helmet Peak---is easterly. The principal ore deposits, lead-zinc and copper, occur as replacement bodies in limestone in or near these faults (excepting south Helmet Peak) along the east fringe of the intrusive granite mass. Granite contacts at depth are reported in the Mineral Hill and San Xavier mines.

Pyritic alteration with minor amounts of copper is confined for the most part to two areas: (1) in the southern portion of the district where it is associated with the lead-silver veins, and (2) in the low hill one-half mile southeast of the Alpha Shaft. This hill, composed of pale reddish-brown colored, east-dipping arkose and conglomerate beds, is completely surrounded by valley fill. Minor amounts of limonite after chalcocite are present in the leached outcrops. Occasional chalcocite, coating disseminated pyrite grains in sericitized arkose is visible on two small prospect dumps located on the southeast edge of the hill where mineralization is relatively strong. A sample of the pyritic material (no visible chalcocite) assayed .6 oz. Ag and .02% Cu. indicating extremely low values in primary copper.

Oxidation is shallow, extending twenty or thirty feet beneath the outcrops.

One mile southwest of the arkose hill (on the lower northeast slope of Lone Peak) a zone of metamorphosed shale outcrops along the edge of the valley fill. Copper mineralization in the form of silicates and oxides is scattered throughout. This and the mineralized limestone gossan on the east end of San Xavier hill are probably related to an eastward continuation of the San Xavier structure as noted on the accompanying map.

The narrow lead-silver veins and associated alteration appear to die out southwest of Helmet Peak, however, possible continuity of the structure is indicated by the easterly displacement of limestone beds at the south tip of Helmet Peak.

Small outcrops of unaltered sandstone and conglomerate are shown in the southeast corner of the accompanying map. These quite likely represent more resistant beds in a very broad mountain pediment. Within this pediment area---over three miles wide---the average thickness of gravel cover should not be great, possibly less than 500 feet.

MINES OF THE DISTRICT

A brief summary of file information on the more important of the known ore occurrences follows:

Mineral Hill Mine

Located on the south edge of Mineral Hill and owned by the Banner Mining Company, the mine has produced something over 50,000 tons of oxidized copper ore and is credited with sulphide reserves of 500,000 tons of 2.5% copper. Minor values in tungsten and molybdenum are associated with the copper which occurs in a south-dipping zone of garnetized limestone. Development, which extends to the 700 level, is in progress, but there is no current production.

Pima Mine

This deposit, concealed by over 200 feet of gravel cover, bears a close resemblance structurally and mineralogically to the Mineral Hill deposit, situated some 4000 feet to the west. The grade of the copper ore in the Pima Mine is considerably higher, however.

The drill exploration, which made the discovery, was reportedly based on a magnetic anomaly obtained in surveys conducted within the past three years by the United Geophysical Company. Development to a depth of 600 feet has indicated a reserve of 500,000 tons of 5% copper sulphide ore. Exploration possibilities appear promising along strike and down dip.

San Xavier Mine

The deposit is a lead-zinc-copper replacement of limestone, which has been developed to a depth of 900 feet by Eagle Picher. Past production amounted to something over 500,000 tons of crude ore. The mine is idle at present.

PROPERTY

The eastern limits of Pima and Eagle Picher Mining Company properties

held under location, taken from a property map compiled by Mr. L. K. Wilson, are shown on the attached map. Mr. Wilson has also advised that no mining claims have been recorded (as of Feb. 20, 1953) on the State and Federal land continuing easterly for over three miles from the present mining locations, and has secured the numbers and locations of several grazing patents in the area. Except for possible unrecorded locations which might exist, all ground east of the present known property limits appears to be open for location.

CONCLUSIONS

Exploration possibilities beneath the gravel cover depend essentially on projection of the known ore-bearing structures into a large area which may contain an extensive zone of alteration; at least, the limits of alteration are not visible in the only existing outcrop (Arkose hill). There appears to be little chance of commercial grades of copper ore in the hill itself, but it could be part of an extensive alteration zone within which stronger copper mineralization of the disseminated type might occur, particularly if granitic intrusives are present.

Deposits comparable to the San Xavier and Pima are not sufficiently large to justify any particularly big risk in exploration, however, these, in combination with a larger objective---such as a porphyry copper deposit ---offer more favorable odds for an exploration gamble. The chances of finding either type of deposit are, however, quite long, being based on geologic permissibility rather than probability.

United Geophysical has tested at least part, if not all, of the gravel covered pediment, using various methods including seismic for depth-to-bedrock determinations. Apparently, they found nothing of interest east of their present claim boundaries. However, as pointed out in the above mentioned memorandum (Jan. 5th), since a positive magnetic anomaly reportedly led to discovery of the magnetite bearing Pima deposit, no significance may have been attached to negative anomalies which may indicate disseminated sulphide mineralization where the magnetite content is lower than normal due to alteration effects.

In considering action that might be taken, it is not likely that the Company could conduct geophysical surveys in the area without attracting attention which might result in serious competition in property acquisition. Since the area of possible interest involves several sections of land, covering it completely with mining claim locations would be a sizeable undertaking. As a first step, we might consider staking a central block consisting of Sec. 7 and the open portions of Sections 1, 6 and 12, plus the south half of 31. This coverage would require about 90 claims, 600' x 1500' each.

A factor to be taken into account is the effect that competitive action by the Company might have on relations with the Pima Mining Company in connection with negotiations for their property. A decision on this aspect of the case is needed at this time.

J. H. COURTRIGHT

JHC:ms
cc: DJPope with map
WRLandwehr "
HERichard "
LKWilson "
MJLacy "

Aa-16.16.20A

J.H.C.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

January 5, 1953

MEMORANDUM TO:
Mr.T.A.Snedden

PIMA MINING COMPANY
Pima County, Arizona

The following notes are based on observations during our visit to the Pima Mining Company's property on December 30,1952. The history of this recent discovery and data available concerning the deposit have been recorded in file memos by Messrs. Welch, Richard and Wilson at various times during the past year. We were able to examine a small amount of new development, but otherwise were not provided with much information in addition to that previously obtained.

Present development extends 300 feet east and 400 feet west of the shaft -- about 300 feet from the Banner property on the west. A short stub drift has been cut on the 500, and sinking to the 600 is in progress (See attached section).

As observed on the 300 and 400 levels, copper values occur as chalcopyrite in a somewhat irregular zone of garnet, chlorite and clay. The higher grade portions (plus 5% Cu) show considerable massive chalcopyrite; the copper in the lower grade (from 1 to 5%) is present mainly as small grains and stringers of chalcopyrite. Minor amounts of magnetite and very minor amounts of pyrite were visible.

Fresh or slightly altered limestone was observed in both the foot and hanging wall on the 400 level; much chloritized limestone occurs within the ore zone as well as on the fringes. Although members of the local University staff have reportedly examined all the drill cores, and determined the ore to occur in an arkose (coarse feldspathic sandstone) formation, I did not recognize any of this type of rock in unaltered areas on either level. It is entirely possible that some of the strongly mineralized portions were formed in sandstone, but identity of such would necessarily require microscopic study. Without having had an opportunity to examine the drill cores, my impression is that the Alpha deposit is mineralogically and geologically comparable to the Banner lying to the west of Mineral Hill. Both deposits appear to occur within an east-west trending, south dipping, zone of faulting. The grade in the Banner is lower (500,000 tons at 2.0% Cu).

The strongest fault structures roughly parallel the zone of ore mineralization both in strike and dip.

Total shipments of direct smelting ore from development through the period May to December of 1952 averaged as follows: (Reported by Mr. Welch)

Dry Tons	Ag	Cu	Ins	Fe	CaO	Zn	S	Al_2O_3
12,243	.86	6.70	36.8	18.3	21.2	.8	8.6	9.7

This analysis shows very little pyrite to be present. Part of the excess iron (above that in the chalcopyrite) is present in the ferromagnesian minerals which have replaced the sediments. The balance of the iron is probably oxide, indicating about 5% as the magnetite content of the ore. Small amounts of molybdenite and scheelite accompany the copper values.

Indicated ore reserves, according to Mr. Drex Spaulding, Manager, are:

From a depth of 220' to 350'

A block 500' long, 130' deep, 70' wide = 455,000 tons @ 3.00%Cu. (10 cu. ft. per ton).

From 350' to 450'

A block 500' long, 100' deep, 25' wide = 125,000 tons @ 5.00% Cu. (10 cu. ft. per ton).

Some underground drilling has encountered ore between the 500 and 600 levels. In view of this and the extent of ore demonstrated on the 400 level, continuity to the 600 may reasonably be expected.

Classed as inferred ore:

From 450' to 600'

A block 500' long, 150' deep, 25' wide = 187,500 tons @ 5.00% Cu.

Total (Indicated and inferred) = 767,500 tons @ 3.8% Cu.

Assuming selective mining of the higher grade in the block above the 350 level, 500,000 tons @ 5.0% Cu appears to be a reasonable expectancy at the present stage of development. The chances appear

fairly good for continuity of structure, and ore, down dip below the 600 level. Surface drilling reportedly did not extend below the 400.

The operators expect to continue development laterally beyond the present limits, indicating that surface drilling has found at least some ore in these areas.

Although for the most part the development drifts have required no timber support, the ground is not particularly firm due to the presence of numerous fractures and slips at all angles. Except in areas of massive garnet, clay alteration has produced a rather soft friable condition in the ore. This effect is probably supergene, consequently it should not persist very far below the present development.

Currently the mine is making about 350 g.p.m. of water.

SURFACE RECONNAISSANCE:

Other than the limestone, quartzite and granite on Mineral Hill, the only outcrop in the vicinity is on a low hill about one-half mile S. 60° E. of the Alpha Shaft. This hill, about one-third of a mile in length, is composed entirely of east-dipping arkose sandstone. The most interesting feature observed was the presence of alteration and the evidence of previously existing disseminated sulphide mineralization throughout. Minor amounts of limonite after chalcocite were noted. On the southeast edge of the hill where mineralization is somewhat stronger, the dumps of two old prospect shafts show that disseminated pyrite was reached at about 25 feet below the leached outcrops. Minor amounts of chalcocite were visible in some specimens.

It is possible that mineralization and alteration in this hill are related to the Alpha zone which projects through about one-fourth mile to the north, however, a few scattered outcrops of sandstone extending to within a few hundred feet of an easterly projection of the Alpha, showed no particular increase in the intensity of mineralization. There is also the possibility that the disseminated mineralization in this isolated outcrop is part of a larger zone extending beneath the gravel cover to the south and east. The nearest outcrops in these two directions are about four miles distant. As yet I have not examined these.

While the hill itself does not appear to hold potentialities, the surrounding gravel may conceal altered intrusive rocks and associated mineralization of possible commercial grade.

United Geophysical has conducted surveys over this covered area and apparently found nothing of interest between Twin Buttes and the Alpha. This may be of little significance however, since their success

in finding the Alpha presumably was due to a positive magnetic anomaly produced by magnetite associated with contact-type mineralization, while anomalies over porphyry-type copper deposits are more apt to be negative due to the loss of accessory and other magnetite through conversion to pyrite during hydrothermal alteration.

Pima Mining Company claims cover the arkose hill but apparently do not extend east of a line running due south.

A further investigation of the surface and of property status in the area is planned in the near future.

J. H. COURTRIGHT

torial "It ain't over till it's support of the

January 8, 1987

James D. Sell
Asarco - Tucson

Dear Jim,

Good to hear from you.

Per your request, attached is some really good work by Harold Courtright at Ely. He lent me the original years ago and said it was "somewhat intended to be a thesis." He wanted to write one though he never had the opportunity.

Cheers and best wishes (prospero año nuevo)

Laurence P. James
Box 226, Golden, Co. 80402

ASARCO Incorporated

JAN 16 1987

SW Exploration

CONSOLIDATED COPPERMINES CORPORATION

MEMORANDUM

FROM J. H. Courtright, Asst. Chief Geologist CITY Kimberly, Nevada

TO Kenyon Richard, Chief Geologist DATE October 2, 1945

SUBJECT GENERAL GEOLOGICAL REPORT --- RICHARD MINE

The Richard oxide copper deposit occurs within a series of overturned limestone beds (Ely) about 1000 feet south of the disseminated sulphide ores in monzonite porphyry. The major portion of the deposit lies between 600 and 800 feet below the surface; lateral dimensions are roughly 200 by 400 feet. The Alpha, another oxide deposit in the flanking sedimentaries, is located 2000 feet northwest.

ROCK TYPES

Limestone. Approximately 500 feet of the Ely limestone formation (Pennsylvanian) is exposed by mine openings in and around the ore deposit. The rock is generally medium gray with numerous sand and chert horizons. The sandy beds contain a maximum of 10% detrital quartz grains in a matrix of calcium carbonate; detrital zircon crystals are usually abundant. Chert occurs as nodules and bands two to three inches in thickness and represents from 10% to 30% of the rock material in certain beds.

Three prominent black marker beds varying from 20 to 40 feet in thickness have been mapped within the ore zone. The upper (stratigraphically) two have the darkest appearance and contain numerous fossils, chiefly coral. The form of these faunal remains is well preserved within the clay which has replaced the encasing limestone. All three beds are slightly sandy and contain moderate amounts of chert. The dark coloration, due perhaps to carbonaceous material, appears to be accentuated somewhat by mineralization and alteration characteristic of the ore zone, the contrast with adjoining grey beds is less sharp within the fresh limestones of the wallrocks.

Monzonite Porphyry. The porphyry occurs as narrow dikes one to three feet in width intruded along the west-dipping fault planes. The general appearance is similar to that of the ore-type porphyry of the district -- a soft, light grey mass with no granitic texture discernible. Nearly all ferromagnesian minerals appear to have been altered. Occasionally less altered portions show remnants of the large orthoclase phenocrysts. Disseminated pyrite is present thruout, except where oxidized to limonite.

A thin section (#393) of the less altered rock shows a few euhedral orthoclase crystals with numerous partially altered ferromagnesian minerals. The groundmass appears as a confused aggregate of rather low birefringent material with indices slightly below the balsam. This material is mairly feldspar plus some clay (?). Zircon is present as an accessory.

Analyses of altered porphyry --- Richard M.: SiO_2 - 49.40, Al_2O_3 --21.09, Fe--7.40, CaO -- .70, MgO--.80,

Analyses of porphyry ore -- Copper Flat Mine (Spencer): SiO_2 -- 64.73, Al_2O_3 - 14.41, MgO--.76, CaO--.44, Fe--2.89.

A comparison of the two samples above indicates that the Richard porphyry has undergone alteration similar to that of the ore type porphyry in respect to the loss of Ca and Mg. The higher alumina content and lower silica may be due to some "kaolinization" process similar to that which formed the clay of the ore material.

Rhyolite. This rock, later than the porphyry, occurs as large irregular masses around the eastern margin of the deposit and occasionally as narrow dikes within the ore. The rhyolite intruding the eastern part of the deposit represents the western end of the large intrusive mass which penetrates the southern margin of the Emma porphyry ore body.

The narrow dikes are often difficult to recognize as they contain fair amounts of delafossite and have the same general appearance as the ore. The presence of a few clear quartz phenocrysts, however, usually serves as a means of identification. A sample taken from a narrow dike contained: SiO_2 --46.20, Al_2O_3 --31.17, Fe--3.40, CaO--.80, MgO--.68, Cu--2.48. No analyses of the fresh, unaltered rhyolite are available, but rhyolites in general usually contain not over 15% alumina and around 60% silica. Thus, as in the case of the porphyry, a process of "kaolinization" appears to have taken place.

ORE

General description. The average ore, composed essentially of clay carrying 4--5% Cu, has a grey, mottled appearance, an effect which on close inspection is seen to be produced by the variations in distribution and size of the small black oxide globules in a rather soft, light grey matrix. Some areas resemble black pepper on cottage cheese. Minor amounts of limonite are present as light brown stains and streaks. Irregular masses of white opaque or light blue translucent clay are not uncommon. The latter usually contains relatively few of the black oxide particles.

The clay minerals occur as metasomatic replacements of both fresh and lightly metasomatized limestones, the latter characterized by a light sprinkling of pyrite and lime-silicates. Sedimentary features such as bedding laminations, chert bands and fossils are quite often well preserved.

Following is a typical smelter analysis: Au --.002, Ag--.010, Cu--4.56, SiO_2 --46.7, Al_2O_3 --17.8, Fe--8.6, CaO--1.1, S--.20, H_2O --14.57. Approximate mineral percentages indicated: Clay--50% (including H_2O), silica (as chert) 15%, as detrital sand - 5%, Delafossite--11%, Limonite and Siderite--7%, Tremolite(?) 4%, H_2O - 5%.

A selected sample of ore containing no visible chert or siderite and only a trace of limonite, gave the following: SiO_2 --33.80, Al_2O_3 - 40.86, CaO --1.70, MgO--1.87, Fe--6.20, Cu--5.85. Assuming the clay to be essentially halloysite (SiO_2 --43.5, Al_2O_3-37.8), this test shows an excess of alumina. Some alumina-silica hydrogel may be present and provide the additional alumina.

Compared to the smelter analysis the above test shows a much higher ratio of alumina to silica. To account for this difference something like 15% silica as chert must be present in the average ore. With the exception of a very few narrow veins of chalcedony, no quartz mineral has been recognized in the ore other than the chert, and a few detrital quartz sand grains. The latter may be responsible for possibly 4% or 5% of the silica.

ORE MINERALS

Delafossite. This mineral, a black oxide of copper and iron, (Cu_2O, Fe_2O_3) is by far the most abundant of the ore minerals. It occurs as small globules averaging about one mm. in diameter in a matrix of light grey to white clay. Size range includes diameters from .1 mm to 10 mm. Occasionally the mineral is present as small irregular masses or veinlets.

Micro...Polished surfaces (Fig.1) show the spherules to be composed of alternating soft and hard concentric layers; the hard material is crystalline with radial arrangement clearly evident. The softer layers do not polish well, but a decrease in crystal size is noticeable along the edges of the hard material; they are considered to be zones of finely crystalline delafossite. Spherules often contain partially replaced grains of native copper or pyrite, or composite grains of covellite and pyrite, or quartz grains.

Chem---While the delafossite globules appear to be relatively pure, it was found that a considerable residue of clay was present after solution in HCl. The following is an analysis of black globules from which all visible clay had been removed: Cu--25.9%, Fe--21.60%, SiO_2--16.90%, Al_2O_3--18.35%. This test indicates a mixture containing approximately 60% delafossite and 40% clay (including water).

Tenorite. While this mineral (black oxide of copper) may be a minor constituent of the ores, no tests were found which would produce positive identification. The above analysis of delafossite globules shows 25.9% Cu, 21.60% Fe. Comparing this ratio to that of the copper and iron in the formula for pure delafossite, it is apparent that the former contains about 6% more copper. This additional 6% may well be present as tenorite (CuO).

Native Copper. This mineral occurs in all sizes from microscopic grains to irregular masses weighing several pounds. Hair-like growths and dendritic crystalline forms are fairly common; spear-shaped forms are somewhat rare. In certain black beds of "kaolinized" limestone native and cuprite are the only copper minerals recognized. A chert nodule (fig.2) which has been replaced by clay contained a radial arrangement of native copper.

In the southern portion of the mine typical black oxide ore carries little more than a trace of native while in the northern part the native (and cuprite) accounts for 25% to 50% of the value.

Cuprite. This mineral occurs as irregular masses and as euhedral crystals.

Of the latter the octahedron is the common form; its luster is adamantine to sub-metallic. The hair-like form, chalcotrichite, is somewhat rare. The cuprite is closely associated with the native copper, the former partially coating or completely enclosing the latter in many specimens. Quite often cuprite crystals, in clusters or individuals are found attached to native. In the "C" black bed octahedrons over ½ inch in diameter were found as constituents of a clay gouge along a bedding fault. Here, a few of the cuprite octahedrons were replaced by spongy native copper.

Azurite. Azurite is found massive, but more often crystalline. The common form is a cluster or roseatte of elongated, chisel pointed blades, about ½ inch in diameter. In economic quantities azurite is found only at, or near, the upper margins of black oxide ores where it is commonly associated with limonite and siderite. One exception to this was noted in 817 stope where a sandy bed contained 10% copper as carbonate (mainly azurite as fine particles).

Malachite. This mineral is found in minute quantities as soft or earthy masses, stalactitic forms or thin coatings on native copper. It is usually associated with azurite and limonite, and is of little or no economic importance as a constituent of the ore.

GANGUE MINERALS

Clay. By far the most abundant of the various gangue materials, the clay occurs as a replacement of both fresh and lightly metasomatized limestone. A. Pabst of U.C. examined X-ray patterns of the ore and tentatively classified the clay as an impure halloysite.

Micro...Thin sections of typical ore (Fig.3) show delafossite, a crystalline clay mineral, amphibole (pargasite?), limonite, detrital quartz and zircon in a matrix of amorphous, colorless material having an approximate mean index of 1.557. According to Winchell the index of halloysite varies with the water content. The above index was determined by oil emersion of material exposed to room temperatures (70 degrees) for several days.

Segregations of relatively pure clay occur as white to light blue masses (sub-translucent before drying) within the ore. This type is more commonly found above the ore in the low grade (1--3% Cu) zones, especially in the central and northern areas of the deposit. It replaces chert (fig.4) and occasionally forms narrow veins cutting the chert ~~(fig.5)~~. A white, sticky variety occurs as coatings or fillings in siderite cavities. Sparse delafossite is usually present. The white, soft, sticky clays and the dense, brittle clays show common optical properties. The indices are variable but usually range around 1.5468-- occasionally as low as 1.526. They are in part isotropic, but mainly anisotropic with low birefringence (plus or minus .003). Fragments extinguish as sharply as quartz and exhibit biaxial figures. The anisotropism may be due to strain.

Chemical analysis of the dense light blue clay (H.S.980), 41.20 silica, 38.82 alumina, shows a lower ratio of alumina to silica than the typical ore material, 33.80 silica, 40.86 alumina. As a possible explanation it is suggested that the "excess" alumina of the latter combined with the silica present (chert, quartz)

to form the segregations of more pure clay. In addition, perhaps, the crystalline clay was completely altered to halloysite. In the typical ore the additional alumina may be present as a hydrogel of some sort. The formation of the more pure clay is considered to be the later part of a process of alteration accompanying the oxidation of the deposit.

Amphibole. The mineral tentatively classified as the aluminous amphibole pargasite is found in the clay ores and also in the lightly metasomatized limestones of the wall rock in the northern portion of the deposit. Megascopically, it appears as tiny lath-like, light gray to white crystalls scattered thru the rock; unusual concentrations are occasionally found as replacements of thin beds.

Micro...It appears as individual, elongated, colorless prisms at random orientation and as sheaf-like aggregates. The approximate indices are, na--1.605, ny--1.62. Elongation is positive and maximum extinction angles range from 16 to 38 degrees in various specimens. No satisfactory interference figure was obtained. The crystals are often partially replaced by clay and (or) siderite. In T.S.394 the clay appears to be replacing the amphibole.

An analysis of material containing about 25% clay (estimate made on oil emersion of powdered rock) (H.S.874) and 75% amphibole (16 deg.ext.) gave the following: SiO_2 -- 45.40, Al_2O_3, CaO -- 8.70, MgO --3.94, Fe --1.80. These results (plus a following analysis) indicate an alumina, magnesia, calcium oxide ratio of 2-1-2 contained in the amphibole. Analyses of three fresh limestone specimens (H.S.936, 937, 938) showed an alumina content varying from 4% to 6% and a magnesia content of from 1% to 3%. Thin sections of these rocks contained no visible minerals other than calcite and amphibole. The maximum extinction angle of the latter was 38 degrees. In a good many specimens the mineral closely resembles (and may be) tremolite. It is quite possible that the variable optical properties (extinction angle) coincide with variations in chemical content.

In respect to the district in general, the aluminous (?) amphibole is the most widespread product of pyrometasomatism, forming an aureole around the more intensely altered sediments of the disseminated copper sulphide zone. The limestones of this inner zone are completely replaced by quartz and "contact" silicates.

Crystalline clay. The mineral is a prominent constituent of the soft, friable gangue material found in the average ore. It is very sparse to absent in the dense, compact, white to light blue clay masses. The crystals are too small to be seen megascopically.

Micro...It appears as a felted mass of colorless, small (.004 mm. average thickness) elongated flakes or shreds embedded in an amorphous material previously described as halloysite. Extinction is parallel; elongation, positive; indices, 1.535--1.58 to 1.59. Birefringent colors are low (white) due to the extremely small size of the crystal plates. A thin section (#467) of a limestone-clay contact showed the crystals replacing the limestone as flakes and shreds along the rhombic cleavage of the calcite. The crystalline clay in turn appears to have been partially altered to halloysite.

Most abundant occurrences are near fresh limestone contacts along the underside of the deposit. The mineral closely resembles hydromuscovite or sericite; however, chemical analyses failed to show potassium. Thus, it is most likely a crystalline clay mineral.

Siderite. This mineral occurs as massive replacement of the limestone. It is of widespread distribution but is found mainly around the margins of the ore body as zones as much as 40 feet in thickness. However, some aluminum silicate was deposited along with the iron carbonate, as shown by the following typical analysis of what microscopically appeared to be pure siderite: SiO_2--9.20, Al_2O_3--14.77, CaO--4.90, MgO--2.17, Fe-33.00. Approximate mineral percentages: siderite--65%, clay (including some aluminum oxide?)--23%, calcite--9%, amphibole (?)--3%.

Numerous cavitites with more or less limonite are characteristically present in the siderite. Occasionally these cavities show a regular pattern, i.e., siderite boxwork. A clean surface on the siderite presents a dull, dark greenish-grey colored, fine grained or dense appearance. Vugs sometimes contain thin mammillary deposits of the vitreous, translucent variety.

Micro...Thin sections show a compact mass of microcrystalline iron carbonate. A few crystals of amphibole are present with good evidence of an earlier age relationship. The clay minerals whose presence is indicated by analysis are not visible under ordinary powers of magnification.

A polished surface (P.S.567) of siderite contains veinlets of fine grained quartz or chalcedony. Pyrite and an unidentified metallic mineral were present in the vein. The quartz and pyrite here are definitely later than the siderite, and are therefore quite likely supergene.

MISCELLANEOUS MINERALS

Gypsum. This mineral occurs around the margins of the clay body as euhedral, clear, transparent crystals (selenite) in cavities or pockets in the limestone. The mineral is most abundant immediately beneath the ore deposit where descending sulphate waters have contacted the calcium carbonate of the unaltered rock. Crystals are found in all sizes, up to 10 inches in length and 2 inches in thickness. The form is usually simple, swallow-tail twins being common. Occasionally the crystals are clouded black with carbonaceous material and contain inclusions of cuprite and native copper.

Pyrite. The mineral occurs in minor quantities as single crystals or small masses in the lightly metasomatized limestone wall rocks of the northern portion of the deposit; it is rare to absent in the relatively "fresh" limestone of the southern part. The monzonite porphry dikes, intruded along fault planes within the deposit and beyond the margins, invariably contain rather even disseminations of pyrite, except where oxidized.

Sphalerite and Fluorite. These minerals occur sparingly as narrow veins in the metasomatized limestone of the northern portion of the deposit. Pyrite and chalcocite are commonly associated with them. In one instance a 2 inch vein of sphalerite (with pyrite, fluorite and chalcocite) was found in a small remnant

of the metasomatized limestone within the ore body. Here, "kaolinization" and the subsequent deposition of delafossite appears to be definitely later than the sphalerite and associated minerals.

Chlorite. A chloritic mineral occurs as a dark green stain and as irregularmasses in the metasomatized limestones around the margins of the clay body. Pyrite is a common associate.

ENVIRONMENT

Churn Drill Hole F-506, which is located in the southern part of the mine, passed thru about 200 feet of sandstone (from the surface downward), 240 feet of silicified, somewhat sandy limestone, 200 feet of "kaolinized" limestone and into fresh limestone at the bottom. The ore occurred in the lower part of the "kaolinized" limestone, immediately above the fresh limestone contact. Although sludge boards and detailed geologic logs are lacking for all the old holes drilled in and around the deposit, the above is considered to be representative of the rock sequence throughout the ore zone.

The ore deposit as a whole rakes at a low angle to the southwest and lies directly across the outer limit of metamorphism in the limestone.

Silicification in the sandy limestone is known to extend from the Veteran to the west end of the Emma. Thin sections of this material show an occasional grain of detrital quartz or zircon in a matrix of fine grained, low temperature type quartz. The silicification may be supergene, -- see paragraph under "Siderite".

OXIDATION RELATED TO ROCK TYPES AND STRUCTURE

In the disseminated copper sulphide ores of the porphyry and metamorphosed limestone leaching has occurred in the upper two to three hundred feet of rock material. At and below this base of oxidation chalcocite has been deposited-- mainly on, or as replacements of, chalcopyrite. Doubtless a relatively stable water table existed for some time. The porphyry and the metamorphosed limestone of the "contact zone" have a tendency to hold the surface waters -- faults and fractures are sealed to some extent by gouge and by mineralization. In contrast, the unaltered limestone (and sandstone) contain open fractures thru which the meteoric waters may readily pass. Thus a draining off has occurred at the margin of the more impermeable rocks. Examples of such water table differentials are found in the bulletin on the Tintic Dist. (Prof. Paper 107, page 20, section thru the Swansea & Sunbeam shafts, also on page 221, a section thru the Lower Mammoth Mine). In the latter relatively deep oxidation associated with clay occurs in the limestone along a monzonite contact.

It is concluded that the circulation of meteoric waters down the contact between the rocks of the disseminated copper belt and the unaltered limestones

effected the transportation of both the clay and the copper from the upper part of the primary zone to a position well below and somewhat south of the same primary zone.

STRUCTURE

General control of clay and ore deposition has been effected by a series of west-dipping normal faults. This system of roughly parallel structures is composed of three individuals and strikes NE thru the south end of the deposit and NW at the north end, forming an irregular, cresent-shaped pattern (see 50 scale plan map). Narrow monzonite porphyry dikes have intruded in and along the fault planes removing the gouge and obscuring to some extent, in places, the exact trend of the faults. A minor amount of post-porphyry movement has occurred.

In the southern portion numerous bedding slips (NW strike, NE dip) offset the NE faults a few feet. In some cases movement has been resumed or continued on the NE faults with a resulting sharp warp in their planes at junctures with the bedding faults. Farther north the faults describe a gentle arc and become less sharply defined--appear to split up or feather out. The total normal stratigraphic separation on the three faults as measured on the black marker beds is well over 200 feet.

COPPER MINERALIZATION

In a general way ore deposition has followed the west-dipping faults, migrating downward along favorable beds and bedding faults. A rude checker-board pattern has been formed by selective mineralization of the offset segments of the various beds. The black carbonaceous beds, although replaced by clay minerals, have been avoided by the delafossite. However, native copper and cuprite often occur in these beds in quantities sufficient to make ore. This copper, which may have been precipitated by carbonaceous material, is confined mainly to the upper or hangingwall portions of the black beds. It should be noted that the black beds are somewhat more dense and brittle than the light colored beds. They may have been relatively impervious at the time of delafossite mineralization, but as the water table receded below the deposit open fractures were filled with native and cuprite. The fractures in the more competent black beds may have been open previous to mineralization of any kind, but the deposition of the delafossite was a process of replacement rather than cavity filling.

In the northern part of the deposit sharp control of ore deposition is less evident. The ores were originally of lower grade (2-3% Cu) but much greater in extent than the small, well defined bodies of the south end. Around the bottom of the "half-bowl" structure formed by the warped fault planes, a 10 to 20 foot zone of 5 to 6% ore occurs-- a result of enrichment thru deposition of finely divided native and cuprite. This condition exists only in a general way; locally, delafossite may be present in sufficient quantities to make ore (plus 4.0% Cu). Notable amounts of native are often found along fault zones and in the chloritic

material occurring at the contact between the clay and the lightly metasomatized limestone of the wall rocks.

GENESIS

In a general way the question of origin involves two somewhat diverse theories: (1) the copper and gangue minerals were derived from a remote source and emplaced in their present position thru the circulation of meteoric waters, (2) the deposit represents a body of primary copper minerals, oxidized essentially in place.

The first stated theory is considered to have by far the greatest weight of evidence in its favor. In a discussion of such a genesis one of the most important factors is the position of the deposit---at the margin of the intensely metamorphosed limestone and porphyry mass where relatively deep circulation of ground waters has occurred. The locus of the primary ores which provided the copper is somewhat obscure. It may have been within the limestone that is now silicified or within the overlying sandstones, or within porphyry or sediments now eroded away. The latter seems the most likely source.

The aluminous silicate which replaced the limestone and formed the clay bodies was probably derived from the rocks containing the primary copper minerals. Ross and Kerr (USGS Prof. paper 135) consider halloysite to be of supergene origin in all cases. They find also that the mineral is not truly amorphous, but is made up of crystals too small for microscopic observation. They state that one important mode of formation is thru the action of cold acid waters (sulphuric acid derived from oxidation of pyritic deposits) on aluminous rocks. G.F.Loughlin (USGS Prof. paper 107, Tintic Dist.) in describing the Dragon Iron Mines, states that the kaolin, leached from the hydrothermally altered volcanics, replaced the underlying limestone.

The clays in the Richard mine were probably formed by a similar process, but the sandstones overlying the deposit could hardly be considered as the source of the aluminous silicate. The possibility does exist, however, that the silica and alumina were leached from the monzonite porphyry and metamorphosed limestone to the north and were carried southward down the fresh limestone contacts. These waters (originally acidic, but later becoming neutral or alkaline) could have effected a metasomatic replacement of the limestone by aluminous silicates. The copper was probably transported by the same solutions. Thus an acid solution carrying, at one time or another, copper, iron, oxygen, silica and alumina, was necessary to the formation of the deposit on a wholly supergene basis.

The form of the clay deposit also strongly suggests a supergene origin, namely, the relatively broad lateral extent, the undulating bottom contacts (section # 1), and the pocket-like form of the various individual ore bodies.

Siderite, as well as clay, has replaced the limestone; however, the age relationship is not clear. Since the siderite occurs commonly at the margins

Supergene action is post-skipolite

of the clay bodies, it may be logically assumed that the siderite is later. Evidently some aluminum silicate was present in the solutions which formed the iron carbonate as this substance is contained in all samples analyzed. The siderite occurs in significant quantities in only two localities: beneath the ore body in the northern portion of the deposit and along the western margin of the south end. A large part of the latter zone contains little or no siderite in the footwall. It is concluded, therefore, that the formation of the siderite was not closely related to the deposition of the black oxide copper ores, but was formed, for the most part, somewhat later.

During or following the formation of the clay body, copper bearing solutions circulating below the water table, soaked thru the clay and deposited the delafossite in rather even dissemination. Although no information is available at the present on the chemical nature of such a process, it is suggested that the neutralizing effect of the clay on acid solutions may have caused the deposition of the delafossite. Certain beds were more favorable than others. This may be a matter of permeability in some cases, such as the black beds. In other instances bedding faults appear to have deflected the solutions. In addition to the foregoing, various beds of limestone were unreplaced by the clay and were thus impermeable. Certainly, the delafossite possessed a strong affinity for the clay. That it did not completely replace the clay but formed a solid solution is evidenced by analyses previously mentioned. Possibly, this same relationship may exist in the case of the siderite and clay.

Minor amounts of pyrite present in the ore (mainly in the northern part) have been partially replaced by chalcocite. In places, such as around the outer margins of the porphyry dikes, the pyrite has been oxidized to limonite. Occasionally a particle of chalcocite (or covellite) was found enclosed in the delafossite; however, there is no evidence of replacement. Often quartz grains or other particles of gangue form centers in the delafossite globules; thus, the chalcocite is considered to be merely incidental. Larger masses of chalcocite observed showed no evidence of being associated with the delafossite. It is concluded that the chalcocite and the delafossite were derived from the same solutions, and that in the absence of pyrite, delafossite was formed.

Conditions somewhat analogous are believed to have existed in the Richard Sulphide body in limestone, located a short distance north and 200 feet above the Richard Oxide. Here, chalcocite occurred in a heavy concentration of pyrite. However, below the pyrite oxides were found. Thus, descending solutions lost only a part of their copper in the pyrite zone and continued downward to form oxides in a sulphide-free environment.

As stated previously, the pyritic porphyry dikes contain no primary and but small amounts of secondary copper (as chalcocite), while the rhyolite dikes are quite often well impregnated with delafossite. A possible explanation lies in the fact that the rhyolite has been more thoroughly "kaolinized" than the porphyry. A definite preference of the black oxide for clay is demonstrated by the fact that the limestone inclusions (subsequently "kaolinized") in porphyry dike margins carry significant concentrations of delafossite. In addition, the porphyry appears to have been somewhat less permeable since chalcocite on pyrite commonly occurs only at the margins of the dikes.

As erosion progressed and the water table was lowered, oxidation and leaching penetrated the upper portions of the deposit, taking the copper of the delafossite (and chalcocite) into solution. Some of the iron may have been precipitated as the ferric hydrate, limonite, the balance was probably carried downward to form siderite at the limestone-clay contacts. A part of the copper formed carbonates, the rest was carried downward to form native and cuprite. In the south end of the mine the deposits of native and cuprite occur in the black carbonaceous beds immediately beneath zones of leaching characterized by abundant limonite and sparse copper carbonates. In the northern part of the deposit black oxide ores of low tenor have been enriched appreciably by native and cuprite. These minerals have been deposited chiefly near the siderite contact at the bottom of the "half-bowl" structure. Here, as in the southwest part (the siderite is not prominent in the southeast area), the siderite and native (and cuprite) appear to be related to the oxidation and leaching processes which followed down after the rece ding water table.

Evidence against the theory of "oxidation in place" is found in the extremely low gold content of the ores. Thruout the district the primary copper (chalcopyrite) contains gold in a ratio which varies little-- 1.0% Cu to .01 Au. Gold assays of Richard Oxide ore (4.5% Cu) run from .001 to .002 Au -- amounts that can be found anywhere in the lightly mineralized limestones or porphyries. The Alpha, an oxide deposit very similar to the Richard, contained like amounts of gold.

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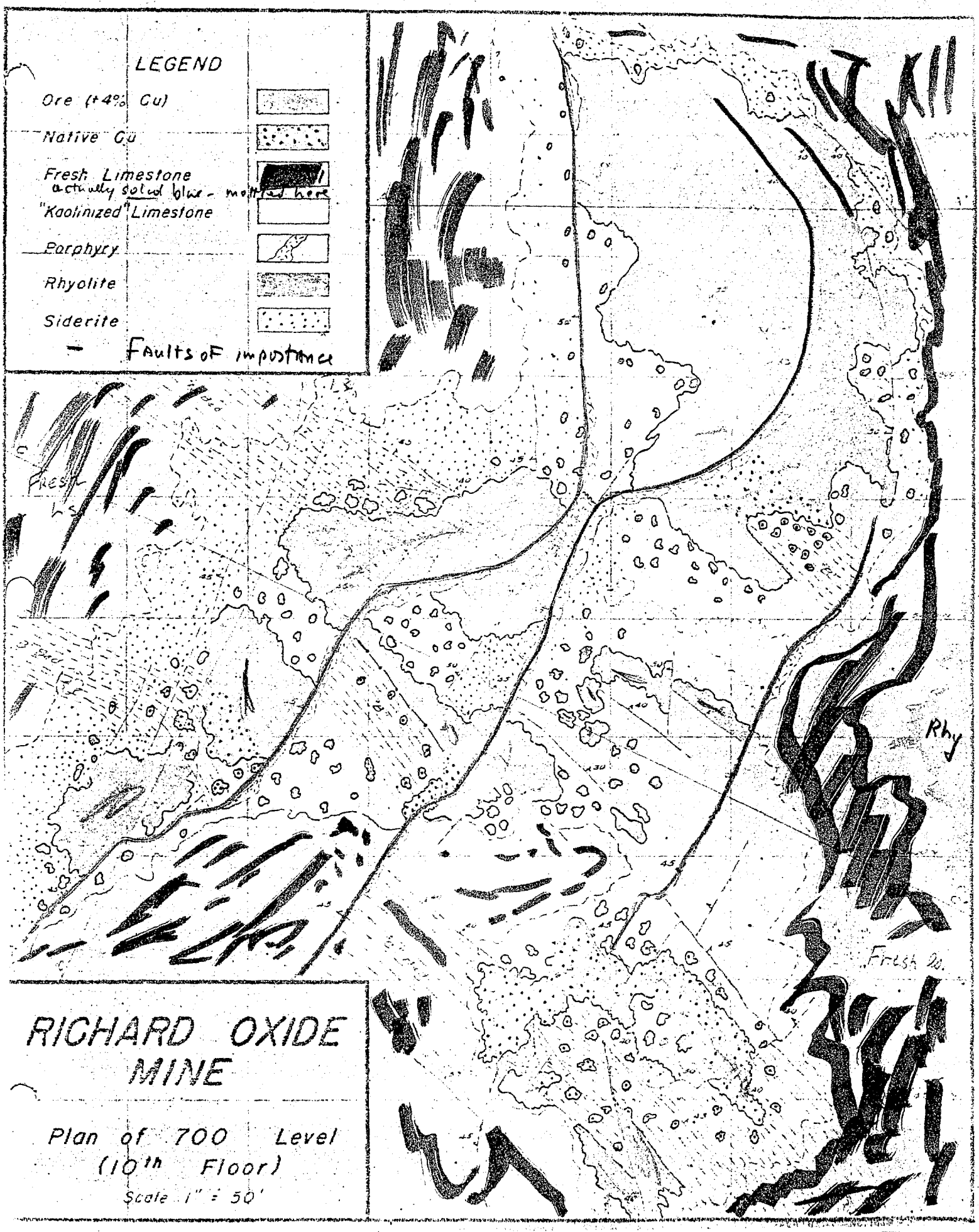
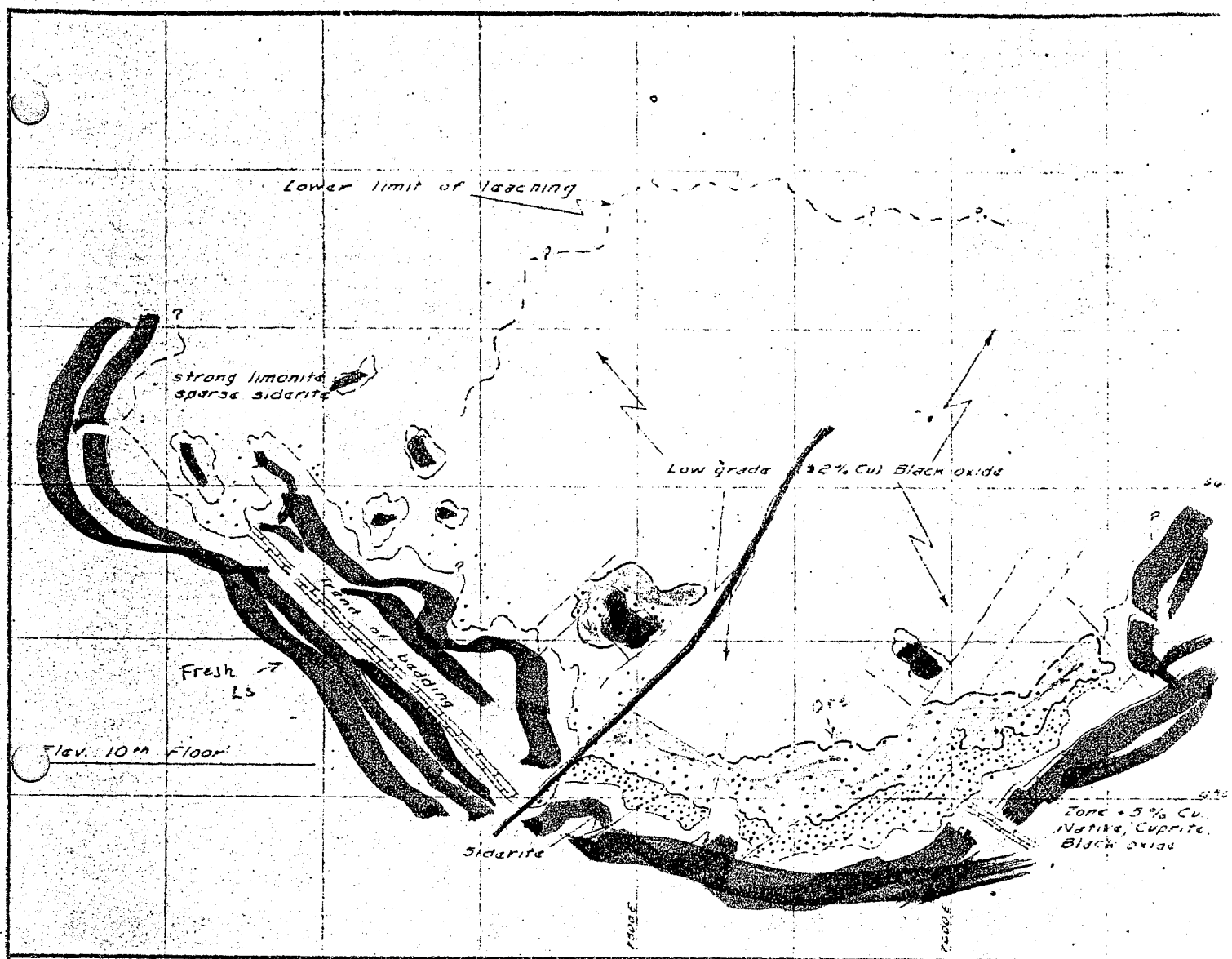
The strongest points in favor of a hypogene origin with oxidation in place are found in, (1) the structural control evident in the deposition of the ores, (2) the selective replacement and mineralization of certain favorable beds, (3) the rather even distribution of the delafossite within various ore bodies (absence of concentration on the surface of structures such as fault planes, footwall fresh limestone contacts, etc.). While (1) and (2) are generally considered features distinctive of hypogene deposits, under the unique conditions which existed in the Richard deposit such features may well have been present in a supergene process. Commonly, supergene deposition of copper is controlled by the position of the water table. In the deposit under discussion the water table was steeply inclined with a more or less continuous downward movement of water, simulating, to some extent, hypogene conditions. In the metasomatic replacement of the limestone by the clay minerals the faults as well as the physical and/or chemical nature of the beds exerted considerable influence. In the case of the deposition of the delafossite, structural control is less evident. The clay bodies, in the manner of a sponge, "soaked up" the copper bearing solutions uniformly, and a more or less uniform distribution of the delafossite resulted. This even distribution is, however, only a local condition; some "kaolinized limestone" beds are low in grade, others are completely barren of copper. It is not clear whether this selective mineralization of beds is due to physical or chemical characteristics.

JHC/mc


LEGEND
Ore (+4% Cu)
Native Cu
Fresh Limestone
actually solid blue - mottled here
"Kaolinized" Limestone
Porphyry
Rhyolite
Siderite
Faults of importance
Fresh
Rhy
Fresh Lm.
RICHARD OXIDE MINE
Plan of 700 Level
(10th Floor)
Scale 1" = 50'



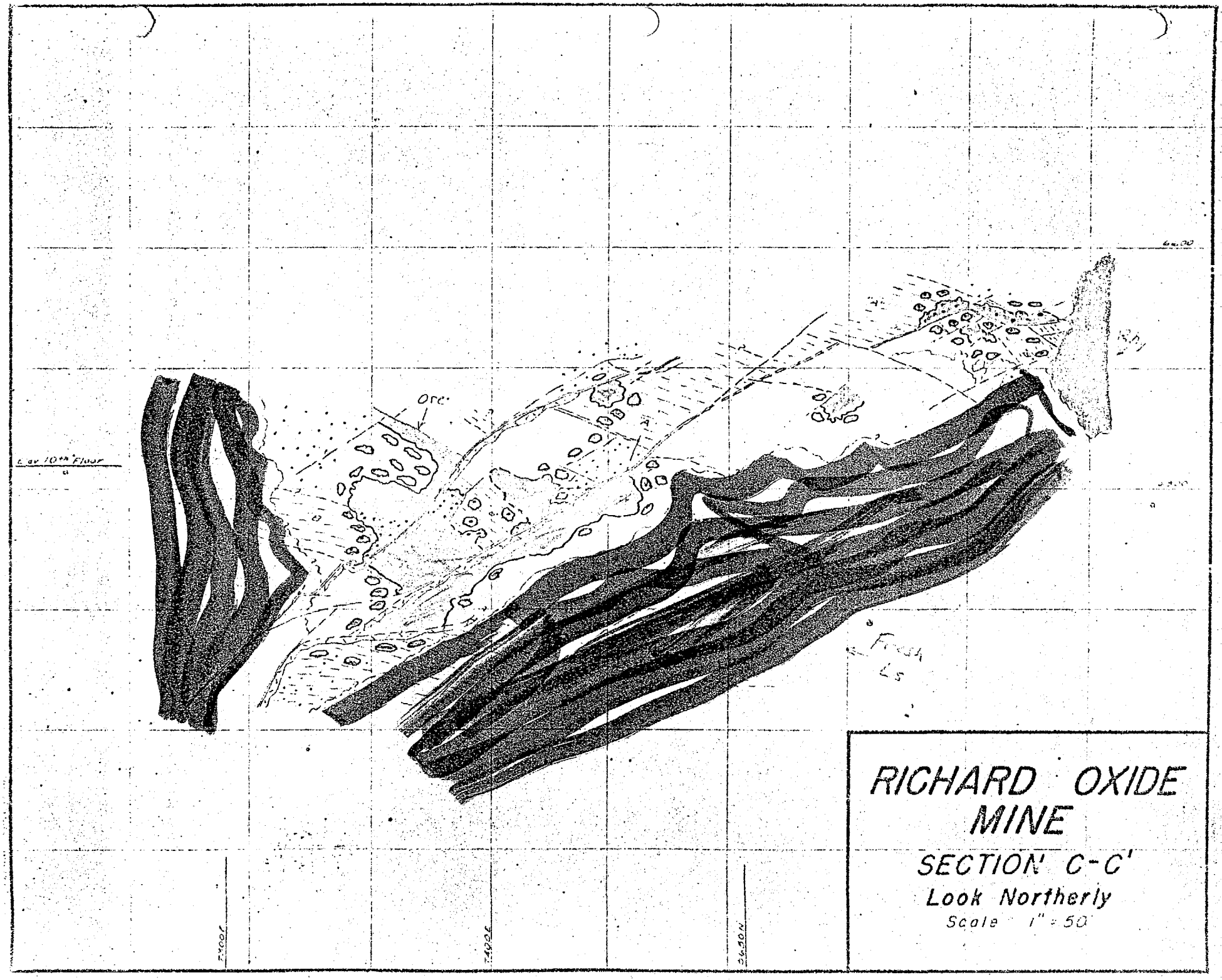
RICHARD OXIDE MINE

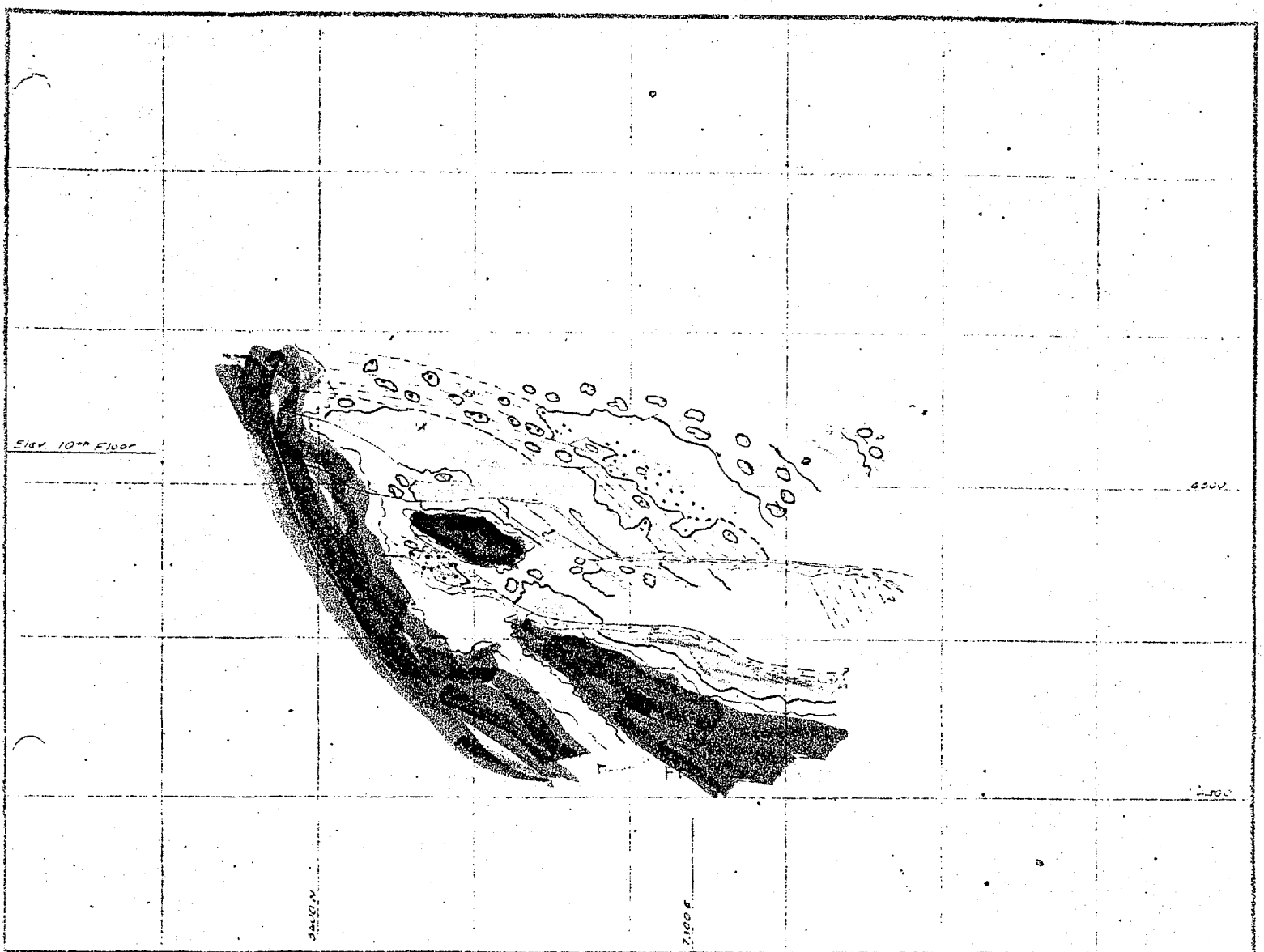
SECTION A-A'

Look North

Scale 1" = 50'

Showing ore body formed by native copper and cuprite enrichment around bottom of clay body containing low grade disseminations of black oxide (delafossite).


Ore
Lev 10th Floor
RICHARD OXIDE MINE
SECTION C-C'
Look Northerly
Scale 1" = 50'



RICHARD OXIDE MINE

SECTION B-B'

Look Westerly

Scale 1" = 50'

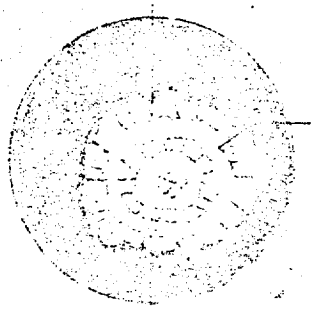


Fig. 1. Polished surface delafossite spherule in clay. X 80

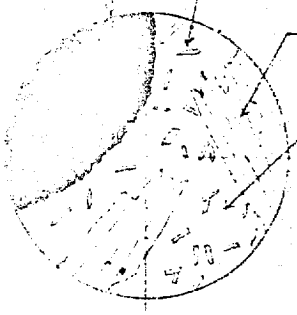


Fig. 3. Thin section of typical ore, northern portion of deposit. X 360

Fig. 2. Sketch showing radial arrangement of native copper in clay "nodule". Natural size. Distribution of delafossite shown by black dots.

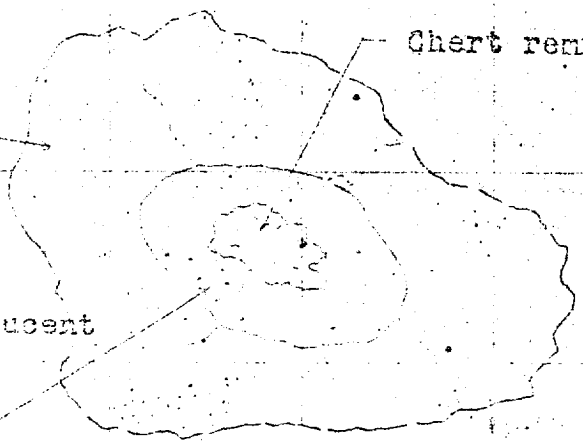


Fig. 4. Sketch showing partial replacement of chert nodule by sub-translucent waxy lustered clay. Natural size.

PACIFIC HISTORICAL REVIEW

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VOLUME LV • AUGUST 1986 • NUMBER 3

Notes and Documents

The Collapse of Western Metal Mining: An Historical Epitaph

MICHAEL MALONE

of the world

ASARCO

Southwestern Exploration Division

November 1, 1984

FILE MEMO

by JHC.

COPPER

The main reason for the depressed state of the U.S. copper industry ---- increased relatively low cost foreign production coincident with decreased Free World demand ---- has been widely publicized; however, actual consumption-production trends over the past several years are less well known.

The attached charts are based on yearly data published by The American Bureau of Metal Statistics, 1957-1983. The first (Fig. 1) shows the strong growth curve of U.S. consumption peaking out in '73 at 2.4 million short tons, with a net decline of 24% 9 years later ('82) ---- reflecting the effect, to some extent, of dips in the economy, but mainly the effect of increasing use of copper substitutes such as aluminum, plastics and fiberglass. Also shown is the even more dramatic rise of consumption in the Free World outside the U.S.A., which peaked in '79, followed by a downward trend through '83. In the same 4 year period, mine production rose over 400,000 tons per year, in contrast to U.S. mine production which dropped by 400,000 tons per year. This Free World production increase, for which State-owned mines in Mexico, Chile and Zaire were largely responsible (Att. 1), took place in the face of falling demand, driving the market price down well below that in 1960, if inflation is taken into account.

Comecon percentage increase in consumption-production (Fig. 1) is even greater than that of the Free World, although the curves are unbroken by sharp ups and downs, as are those of countries with less controlled economies. The gap between mine production and consumption is filled principally by recycled scrap; that is, refined production (not shown) approximately equals consumption.

Free World refined annual production (including U.S.A.) rose from a dip in '75 to around 8 million tons in '81-83 while consumption dropped from an 8.3 million peak in '79 to 7.6 million in '83 ---- 0.4 million tons excess production (Fig. 2). Only a minor gain in consumption occurred during '83, the year of economic revival, which was solely due to the U.S.A. increase. U.S.B.M. data shows a much sharper increase in '83 for U.S. consumption and a continued rise for the first 8 months in '84 (Fig. 1).

Reflecting over-supply, the U.S. producer price fell from 102.4¢ per lb. for 1980 to the drastically low level of 62¢ in Oct. '84. The real price (inflation adjusted) fell even lower, and, as indicated by the following tabulation, the current price in '81 dollars is around 56¢ compared to

to 90.5¢ in 1960. Thus, today's price would be well under the historic low of the '30's* in '81 dollars.

Table 10.—Time-price relationships for copper

Year	Average annual U.S. producer price[1] (cents per pound)	
	Actual price[1]	Based on constant 1981 dollars
1960	32.1	90.5
1961	30.0	83.8
1962	30.8	84.5
1963	30.8	83.2
1964	32.6	86.8
1965	35.4	92.2
1966	36.6	92.4
1967	38.6	94.6
1968	42.2	99.0
1969	47.9	106.9
1970	58.2	123.3
1971	52.0	104.9
1972	51.2	99.2
1973	59.5	109.1
1974	77.3	130.3
1975	64.2	99.0
1976	69.6	102.1
1977	66.8	92.5
1978	66.5	85.9
1979	93.3	111.0
1980	102.4	111.8
1981	85.1	85.1
1982	74.3	70.1
1983	76	71
1984 (9 mo.)	68	± 56

[1]U.S. producer price, electrolytic wirebar copper, delivered to U.S. destinations basis.

Table 11.—Average copper production costs, January 1981[1]

(Cents per pound of copper)

	United States	Foreign Countries
Mining	33	33
Milling	34	22
Smelting and refining	35	24
Miscellaneous costs	5	7
Total operating cost	106	85
Taxes	5	9
Byproduct credits	(19)	(27)
Net operating cost	92	68

[1]Totals may not add to totals shown because of independent rounding.

Also shown in the above is the large disparity between domestic and foreign (Free World) production costs per lb.: 92¢ vs. 68¢ for 1981. Excluding taxes of 5¢ and 9¢ per lb., respectively, the costs are: 87¢ vs. 59¢.

In a talk given for a meeting of security analysts on 7-26-84, T.C. Osborne concluded that U.S. copper production costs had been reduced substantially since 1981, approaching the average of foreign producers. His estimates for '84: U.S. - 72¢ per lb., Western World - 68.7¢ per lb. (lowest cost country, Chile at 50¢ per lb.).

* '30-'39 average actual price = 10¢ per lb.

Probable Free World demand for primary copper has been projected to be 12.5 million metric tons by the year 2000 for an annual average growth rate of 2.3%*. However, a mine production increase of 80% (1 million metric tons) by 1990 is planned by Chile** alone, which, if carried out, could mean a probable over-supply of copper for a long time to come, assuming no significant cut-backs by the other foreign producers.

J. H. Courtright

J. H. Courtright

JHC:mek

*Mineral Commodity Profiles, 1983.
**EM&J, April '84.

cc: R. L. Brown
F. T. Graybeal
W. L. Kurtz
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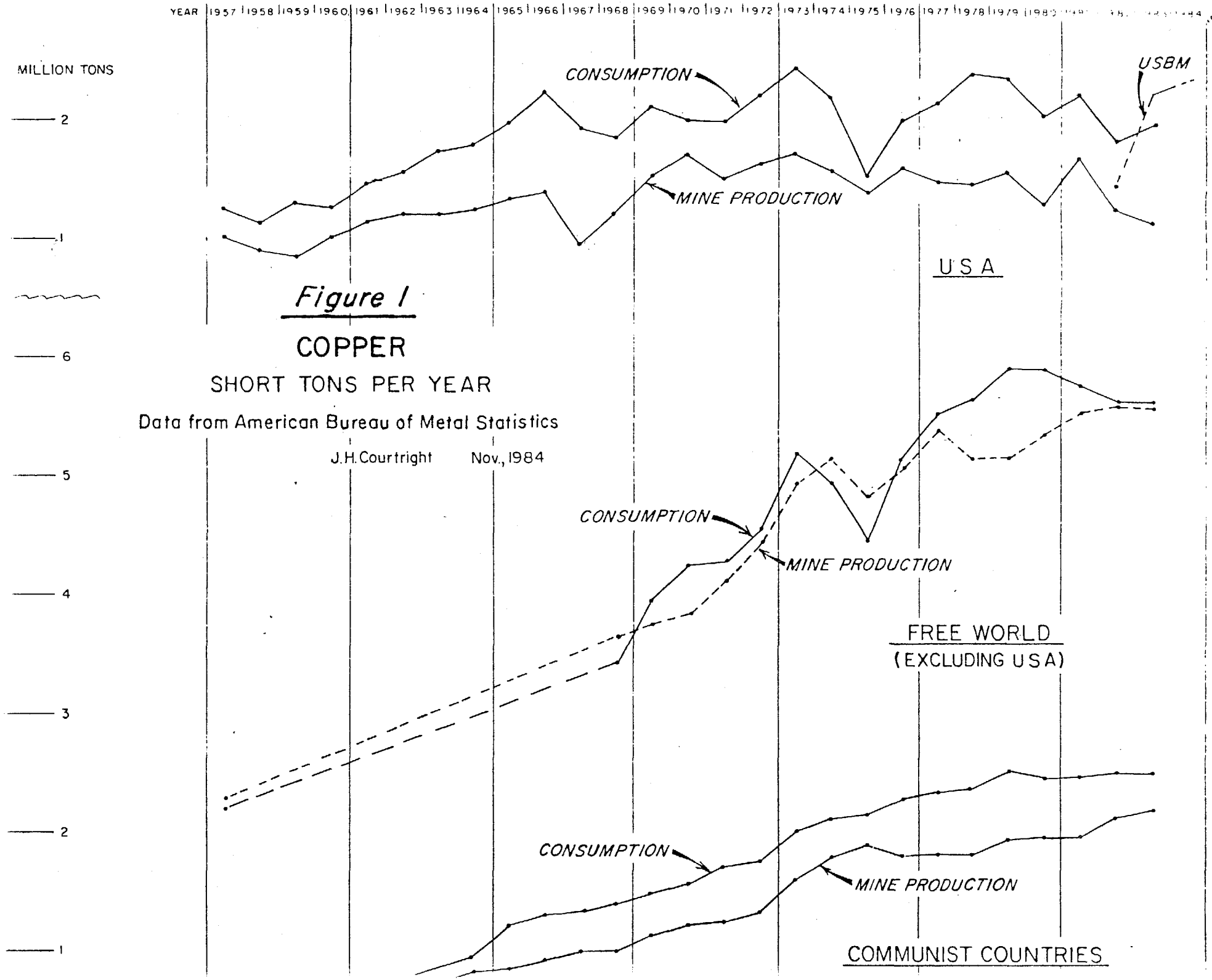
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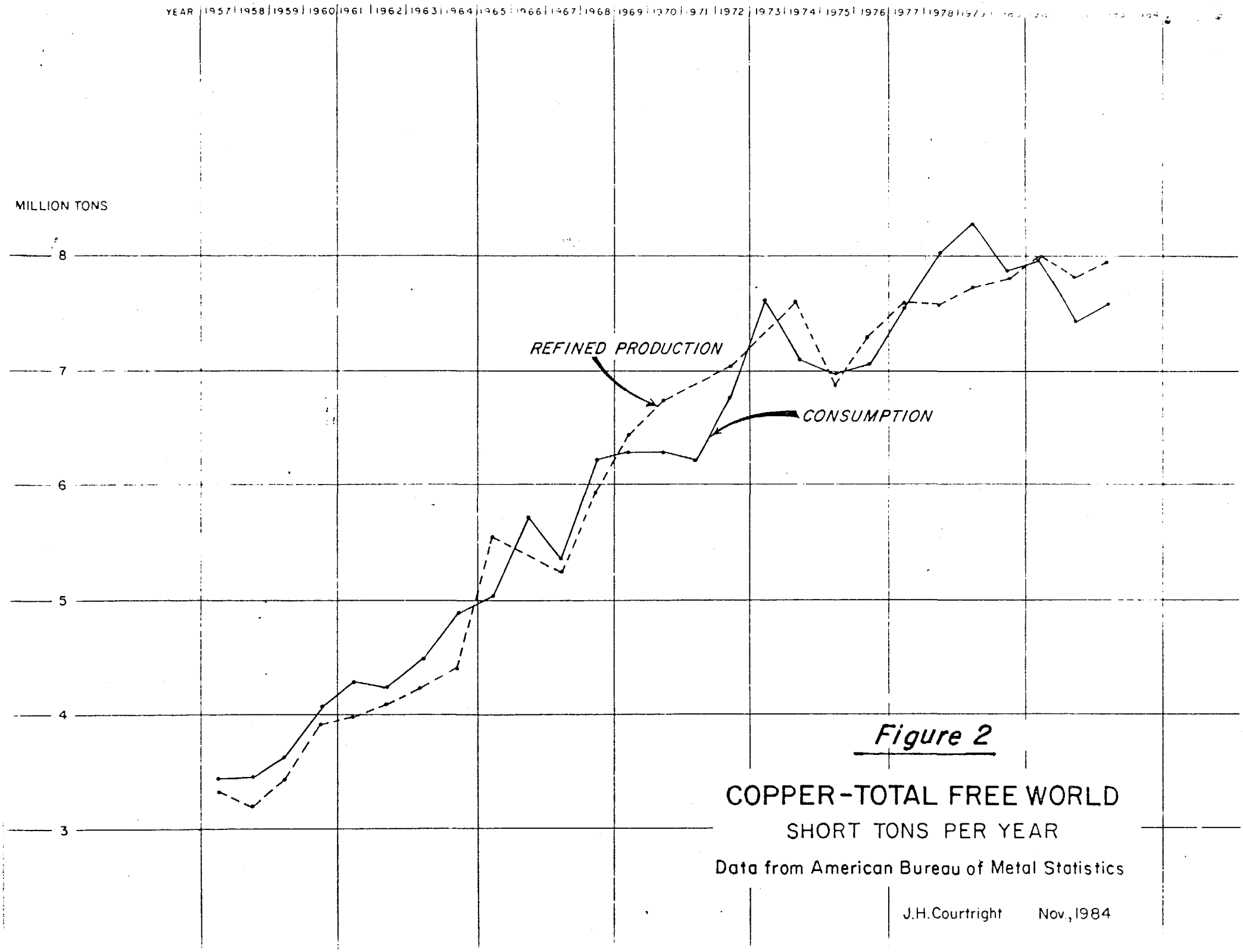
CONSUMPTION
MINE PRODUCTION
USBM
USA
Figure I
COPPER
SHORT TONS PER YEAR
Data from American Bureau of Metal Statistics
J.H.Courtright Nov., 1984
CONSUMPTION
MINE PRODUCTION
FREE WORLD
(EXCLUDING USA)
CONSUMPTION
MINE PRODUCTION
COMMUNIST COUNTRIES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MILLION TONS
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3
REFINED PRODUCTION
CONSUMPTION
Figure 2
COPPER-TOTAL FREE WORLD
SHORT TONS PER YEAR
Data from American Bureau of Metal Statistics
J.H.Courtright
Nov., 1984

COPPER

World Mine Production Of Copper

Thousands Of Short Tons

	1979	1980	1981	1982	1983
United States	1,591.2	1,301.9	1,695.5	1,256.1	1,152.7
Canada	701.5	789.7	762.1	675.1	688.9
Mexico	118.1	193.3	254.1	263.6	210.5
Cuba	3.1	3.6	3.2	3.0	2.9
Guatemala	2.2	0.9	–	–	–
Argentina	0.1	0.2	0.1	0.1	–
Bolivia	2.0	1.9	2.9	2.5	2.3
Brazil	–	0.4	15.3	27.0	44.0
Chile	1,171.4	1,177.2	1,191.7	1,367.6	1,372.5
Colombia	1.2	1.5	0.8	0.4	–
Ecuador	1.3	1.0	0.9	0.1	–
Peru	437.8	404.2	361.1	392.8	347.0
Total America	**4,029.9**	**3,875.8**	**4,287.7**	**3,988.3**	**3,820.8**
Finland	45.3	40.6	42.1	42.1	41.6
France	0.1	0.1	0.1	0.1	0.1
Germany, F.R.	1.0	1.4	1.5	1.4	1.3
Greece	–	0.1	0.1	–	–
Ireland	5.3	4.6	3.9	1.8	–
Italy	0.6	0.7	0.9	0.1	1.7
Norway	31.6	31.9	31.1	30.8	28.9
Portugal	4.0	4.6	3.2	2.8	4.3
Spain	47.7	52.4	62.8	64.0	59.6
Sweden	50.5	47.2	55.9	61.1	71.1
United Kingdom	–	0.2	0.8	0.7	0.8
Yugoslavia	122.8	128.7	122.4	131.5	150.0
Total Europe	**308.9**	**312.5**	**324.8**	**336.4**	**359.4**
Burma	0.1	0.1	0.1	0.1	–
Cyprus	1.3	–	–	0.9	1.3
India	30.5	30.4	27.8	26.5	27.0
Indonesia	66.4	65.0	69.0	82.8	88.6
Iran	3.3	1.1	2.2	47.4	46.3
Israel	–	0.4	4.9	4.5	5.3
Japan	65.1	58.0	56.8	56.2	50.7
South Korea	0.6	1.0	1.2	1.5	2.4
Malaysia	27.0	29.8	31.5	34.1	32.1
Oman	–	–	–	–	13.2
Philippines	328.8	335.7	333.2	322.0	299.2
Taiwan	0.7	0.6	0.6	–	–
Turkey	34.0	23.5	37.0	34.6	29.8
Total Asia	**557.8**	**545.6**	**564.3**	**610.6**	**595.9**
Algeria	0.2	0.2	0.2	0.2	0.1
Botswana	16.1	17.2	19.6	20.3	22.4
Congo	1.1	1.4	0.2	0.1	–
Morocco	9.1	9.3	8.4	23.0	21.2
Mozambique	0.2	–	–	–	–
Namibia	46.2	43.2	48.8	53.8	59.7
South Africa	224.0	233.6	232.1	228.3	226.0
Zaire	440.7	506.7	556.4	554.2	553.9
Zambia	648.5	656.8	647.5	583.8	566.1
Zimbabwe	32.6	29.8	27.1	27.3	20.9
Total Africa	**1,418.7**	**1,498.2**	**1,540.3**	**1,491.0**	**1,470.3**
Australia	261.9	268.4	255.0	270.4	291.7
Papua New Guinea	188.3	161.8	182.3	187.4	201.9
Total Oceania	**450.2**	**430.2**	**437.3**	**457.8**	**493.6**
Sub Total	**6,765.5**	**6,662.3**	**7,154.4**	**6,884.1**	**6,740.0**

(continued next page)

From: R. L. Brown

To: Harold Courtright
Tuscon Office

This is the end result
should come out in a
February issue of
American Metal Market

ASARCO Incorporated

DEC 31 1980

... exploration

Check for copy in print

COPPER SUPPLIES INTO THE NEXT CENTURY

by Richard L. Brown and James H. Courtright

Even though copper supplies have been adequate or have even been surplus during most of the years since the industrial revolution, users of copper occasionally inquire of the mining geologist if supplies of this metal will continue to be adequate over the long term.

While there may very well be a shortage of refined copper in the marketplace during the balance of this century, such will be a temporary phenomenon caused by the lack of investment capital (due mainly to the unremunerative prices of the past decade) for new copper properties, more than to the lack of copper minerals in the ground. Concern over copper's future is no doubt appropriate, it being, next to iron, perhaps the most vital of all metals to modern life.

In the following paragraphs the writers will explain why they ~~he~~ consider that while copper may be in short supply during the short term, supplies should be adequate over the long term.

A good proportion of future production will come from some of the huge porphyry copper deposits which were discovered and placed into production shortly after the turn of the century. These deposits contained enormous amounts of copper mineralization, but with some exceptions the only feasible way to mine them economically was to utilize rail haulage in open pits --- loading the broken ore into trains by large shovels which themselves were moved on rails. This equipment was not flexible and the employment of it was feasible only in large deposits.

In some of the early porphyry coppers, considered then to be small and deep, a system of block-cave mining was devised. In this, open spaces under large blocks of ore are created, and following an initial blast, ore caves naturally into the openings. As this ore is removed, even more material caves into the opening until the ore-block is mined out. Subsequently, new and contiguous blocks are undercut and extracted in the same way.

For various scientific reasons, most porphyry copper deposits are zoned something like onions, the core of the onion containing more copper than in outer layers. Miners of course excavate the richer central portions of the deposit first, thus, the amount of copper contained in each ton of ore mined in each year in typical mines, falls slightly. Accordingly, at some point in time all the porphyry copper operations will become submarginal in grade. In the past this problem has been solved by reducing costs per ton (larger more efficient mills and mining equipment), resulting in a substantial decrease in the average grade of ore mined in the U.S.A. (from 1.8% Cu in 1920 to .63% Cu in 1975, USBM data). However, this declining curve is now essentially flat due to the fact that the copper price has failed to keep up with inflation. Nevertheless, porphyry deposits will likely continue to dominate the production scene.

During the second World War, diesel-powered trucks were developed and these, together with more mobile loading equipment, made possible economic production of copper from small deposits in which rail haulage would not be feasible. When the economics of a few such smaller producting porphyry coppers became evident, a dramatic

increase in exploration activity and subsequent production of copper from relatively minor sized deposits occurred. Some of these will have relatively short lives, but others will be substantialy producers for many years.

There has been far more discovery of copper deposits than there has been development of them. There are perhaps 18 or 20 undeveloped porphyry coppers in the Western Hemisphere, which will remain dormant until copper is priced high enough to demonstrate to investors that a reasonable return can be achieved. Various analysts suggest that a copper price between $1.70 and $2.40/lb. in 1980 dollars, will be required to trigger new investments. It can reasonably be stated that these 18 to 20 undeveloped porphyry coppers only contain copper to meet demand for the next 20 years as few individual copper deposits contain enough to meet a year's world annual consumption. It can be also argued that the early porphyry coppers found at the turn of the century by prospectors, and that most of those found subsequently, were all discovered in outcrop -- that is to say could be seen at the surface of the ground. Further arguments suggest that while the occasional outcropping copper deposits may be found in future years, such discoveries will be very rare.

Mineral economists and hard metal explorationists have given considerable thought to the entire matter of future metal supplies. Many such people consider that adequate availability of metals will continue because of their relatively high abundance in the earth's crust. If it is an abundant constituent, concentrations of the metal should, at least in theory, be assumed to be fairly numerous.

However, as compared, say, to iron, which composes 5.0% of the earth's crust, copper which makes up less than .005%, is only modestly abundant.

Others have endeavored to identify those portions of the earth's crust where copper concentrations are most likely to occur, and conclude that a large majority of such areas are covered by recent volcanic ejecta, by desert sand, and by other material through which geologists cannot easily see.

The next question to be asked is can geologists in fact find deposits in the rocks which are hidden from their view. The answer to this question is that they have already done so, are doing so, and will continue to do so at an increasing rate as soon as the price of copper justifies the effort. Examples of what can be done by geologists using mainly deductive techniques are becoming more common. For instance, in September 1970, Kerr-McGee announced the discovery of copper concentrations in Southern Arizona at depths of 3400-5200 ft. More recently, a joint venture owned by Hanna Mining and by Getty Oil announced in October 1975 that they had found in Arizona 256 million tons of material grading 1.0% copper at depths of 1600 to 3300 ft. under desert sands. In September 1976, an extraordinarily large deposit at Roxby Downs in Southern Australia, was announced by Western Mining Corporation Ltd. This deposit tops at about 1000 ft. beneath the surface. Although not publicized, there are probably as many as 10 other such discoveries of perhaps somewhat smaller size within the Southwestern United States alone.

The next obvious question to be asked is will these deposits, existing at depths described above, be economic at any price of copper? This is a fair question, given the depths involved. The answer, of course, is that similar deposits are already being mined in many parts of the world. Traditional block-caving techniques are employed at the molybdenum mine at Henderson, Colorado, down to 4000 ft. Copper is now being mined at San Manuel, Arizona, at least to depths of 2600 ft. At Carr Fork, Utah, copper is and will be mined, not by block caving, but by another and more modern method at depths of 2000-5000 ft. However, it must be pointed out that due to excessive inflation of capital costs, San Manuel for instance, could not be developed (and operated at a reasonable profit) at this time unless the grade was double the existing average; that is, around 1.50% copper!

While traditional mining methods will be used in some of the predicted new discoveries improved extraction, techniques will probably be employed in others. One of these is in-place leaching. Certain types of ore contain acid-soluable copper minerals. If sufficient permeability exists, or can be created (by blasting for example), acid solutions may be percolated through a deposit, and then collected, pumped to surface, and stripped of its copper in a surface plant --- at a much lower cost per pound than incurred in conventional mining.

Occidental Minerals Corporation has an advanced project of this type at Miami, Arizona. Similar experiments are being carried out elsewhere in Arizona. At other places in Arizona, ore is

mined by traditional methods, but the copper is being won from the ore, not by the usual milling process, but by spraying a sulphuric acid-water solution on piled ore, and then recovering the copper as in the above-mentioned in-place leach process. Incidentally, leaching of mine waste dumps has accounted for around 10% of production in the Southwest.

There is enough evidence in already to support optimistic projections as to future copper supplies. Undoubtedly, a substantial proportion of this copper will come from new mines located in areas far from currently producing districts.

It will require sharply increased copper prices to trigger the exploration and development of these new mines. The owners of producing mines will prosper as long as their currently equipped mines last. However, the current producers and new producers will require sharply increased copper prices to trigger new exploration and new mine investment. In the United States, drastic changes in attitude toward mining, smelting and refining activities must occur in such a way that a greater proportion of available cash flow can be directed at new production; rather than with coping with environmental restrictions, if U.S. copper is to become competitive in world markets.

ASARCO

Exploration Department

James D. Sell
Manager

September 1, 1993

Mr. Francis R. McAllister
Executive Vice President - Copper Operations
Mr. Gerald D. Van Voorhis
Vice President - Exploration

Bootprints Along the Cordillera

Dear Francis and Gerry:

"Bootprints Along the Cordillera," a symposium on Porphyry Copper Deposits from Alaska to Chile, is being announced in the September issue of the AIME Mining Engineering magazine, and will be announced in a number of other publications in the near future.

"Bootprints" will be dedicated to Asarco geologists Kenyon E. Richard and J. Harold Courtright, the original members of the Asarco Exploration Department, for their achievements in porphyry copper geology and exploration.

The "Bootprints" committee respectively requests Asarco to support the symposium with a corporate contribution of $10,000. We are also requesting similar contributions from Phelps Dodge, Cyprus, and Magma, the major copper producers from Arizona.

Our overall goal for this fund raising is $75,000 to $100,000 total contributions from other mining, exploration, drilling, assayers, consultants, and support groups throughout North and Central America.

The use of the funds would be to keep the registration fee as low as possible, support of lunches, banquet, receptions, publication of the proceedings volume, the field guide volume, and general support of the total symposium cost.

The registration fee would include attendance at the sessions, three lunches, a welcoming party and the proceedings-field guide volumes.

The symposium is scheduled for October 5, 6, and 7, 1994, with field trips before and following the meeting. Nine sessions with about 27 verbal presentations; seventeen field trips from Montana through Nevada, Utah, Arizona, Mexico, to Chile; a welcoming party, a reception and banquet, and spouse's activities are all planned. Guest speakers at lunch on each of the three days, as well as a banquet speaker of porphyry copper note, are being arranged.

ASARCO Incorporated P.O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue FAX (602) 792-3934 Phone (602) 792-3010

An exhibit by Vendors and poster sessions by students and others is also on tap.

The symposium committee is composed of the following:

James D. Sell	Asarco	Co-General Chairman
Charles P. Miller	Consultant	Co-General Chairman
Jan Wilt	Consultant	Program Chairman
Anna Domitrovic	AZ Desert Museum	Logistics Chairman
Frances Pierce	U.S. Geol. Survey	Co-Digest Chairman
John Bolm	Attorney	Co-Digest Chairman
Joseph Wilkins, Jr.	Consultant	Field Trip Chairman
Will Wilkinson	Phelps Dodge	SME Liaison/Prog.Ch.
Brenda Houser	U.S. Geol. Survey	AGS President
James Laukes	Extended UofA	Conference Services

The proceedings volume and field guide volume of plus 700 pages, will be published by the Arizona Geological Society. The volumes will have the pages from the 27 talks, plus about an equal number of other papers. All papers have been requested and the volume committee will prepare the volumes for publication prior to the meeting.

The University of Arizona Conference Services has been engaged to handle the logistics and general planning, under the direction of the symposium committee, with the symposium and exhibits to be held in the Tucson Convention Center complex.

As noted in the attached flyer, the emphasis of the "Bootprints" symposium is on the descriptive presentation of porphyry deposits, techniques, and procedures applicable to porphyry copper exploration.

We anticipate between 800 and 1000 attendees as the re-birth of copper exploration swings into the mid-1990's.

The Asarco contribution payable to the "AGS Bootprints Symposium" will be greatly appreciated.

Sincerely,

James D. Sell

James D. Sell

JDS:mek
Att.

Arizona Geological Society, United States Geological Survey and Society for Mining, Metallurgy, and Exploration, Inc.

Announce

Bootprints Along the Cordillera

a Symposium on

Porphyry Copper Deposits from Alaska to Chile

October 5, 6, and 7, 1994
Tucson Convention Center, Tucson, Arizona

This tribute to J. Harold Courtright and Kenyon E. Richard celebrates their talents and accomplishments in the field of porphyry copper exploration and development

Highlights include:

- ☆ Site-specific case studies
- ☆ Regional overviews
- ☆ Geochemical and mineralogical characteristics of calc-alkaline porphyry copper deposits
- ☆ New exploration techniques using alteration and fluid inclusions
- ☆ Volatiles and calc-alkaline melts
- ☆ Supergene enrichment
- ☆ Application of remote sensing to studies of porphyry copper deposits

Field trips include:

- ☆ Visits to porphyry copper deposits in the Western U.S., Mexico, and Chile

For more information contact:

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