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~~JHS~~

MINERALOGISCH-PETROGRAPHISCHES INSTITUT
DER UNIVERSITÄT HEIDELBERG
Prof. Dr. G. C. Amstutz
Direktor

D-6900 HEIDELBERG 1,
Postfach 10 4040
Im Neuenheimer Feld 236
Telefon (06221) 562802/11

J. H. C.
MAY 9 1983

Dr. J. H. Courtright
Exploration Geologist
2o2 Suffolk Drive
Tucson, Arizona 85704
USA

2o April 1983

Dear Dr. Courtright,

thank you so much for sending me the China mine's tour description which will help me a great deal in my planning.

Thank you also very much for your guidance and the many interesting discussions during our Silver Bell Tour.

Thanks I placed it with the Library copy of Ramdohr "Ore minerals"

Enclosed is our last list of reprints which may give you a little cross section through our activities in Heidelberg.

If you are ever in this part of the world, I would be very happy to welcome you to our Institute.

Yours sincerely,

Chris

Encl.

G. C. Amstutz

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Branch of Pacific Mineral Resources
345 Middlefield Road
Menlo Park, California 94025

RECEIVED
APR 30 1971
EXPLORATION DEPT.

April 28, 1971

J. H. C.
MAY 24 1971

Mr. J. H. Courtright, Chief Geologist
Exploration Department
American Smelting and Refining Company
P.O. Box 5747
Tucson, Arizona 85703

Dear Harold:

Your letter of March 22 arrived while I was in Arizona doing some rechecking around the Jerome country, hence my tardiness in responding. A copy of your letter was forwarded to Dr. Hopwood, so you should be hearing from him soon. Thanks very much for your advice on how to arrange a visit to the Mission Mine.

I enjoyed reading the paper by Barry Watson on the intrusive volcanic rocks in southern and central Arizona. The distinction between intrusive and extrusive volcanic rocks can be difficult, and I suspect that only detailed mapping will reveal the answer in many areas. I can appreciate this problem as I am trying to make this distinction in the Jerome area. I thought I had it solved once, but the answer is not clear cut.

Thanks for the invitation to visit you some winter and review some of the occurrences in the Santa Ritas. I hope that I can accept sometime in the near future.

Sincerely yours,

Andy

Charles A. Anderson

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

July 7, 1966

Mr. John J. Collins
Building

A Metamorphosed Zone of Precambrian
Secondary Copper Enrichment

Dear John:

Your paper describes a definitely unique copper occurrence, and I believe when published will be a significant contribution to economic geology.

I have a few suggestions which are listed below:

Page 1, Item 1: "fresh" is not appropriate since rocks other than fresh have not so far been mentioned.

Page 1, Item 2: Suggest "barren, except for exotic copper".

Page 1, Item 3: Since the zone of mineralization is in the phyllite, "between the two rocks" is incorrect. Also, "indurated" does not seem appropriate.

Page 1, Item 4: "progressively" in what direction? Suggest deletion.

Page 1, Item 5: "mushy" might be replaced by "gossan-like", or "ferruginous conglomerate", or "mottled".

Page 1, Item 6: Suggest substitute "this zone" for "this assemblage". Suggest deletion "now metamorphosed".

Page 1, Item 7: The reader has not yet been informed of the position of the attitude of the contact.

Page 1, Item 8: Suggest "probably occurred".

Page 2, Item 9: Suggest "underground work".

Page 5, Item 10: The contact is not the zone, but occurs at the top of the zone.

Page 5, Item 11: Again, I think something more descriptive should be used here.

Page 6, Item 12: Perhaps "mineralization" should be substituted for "orebody".

Page 6, Item 13: Except for "revealed", present tense is used elsewhere. Substitute "is" for "was", etc.

Page 6, Item 14: Suggest "dolomitic mudstones". The fact that they are calcareous should not change the classification.

Page 8, Item 15: Explain the meaning, or delete this sentence.

Page 8, Item 16: Suggest delete "only".

Page 8, Item 17: If this is to be the other of the two impressive faults, it should deserve description.

Page 9, Item 18: Suggest "grade" or "quality" as a substitute for "quantity", or better, delete as superfluous.

Page 9, Item 19: Suggest revision as noted on page 9.

Page 10, Item 20: Suggest revision as noted on page 10.

Page 10, Item 21: If you mean bedrock surface, iron oxides are prominent. This should be qualified---"surface of the soil mantle or talus".

Pedra Verde Section, Item 22: Suggest showing on the section the unconformity at the base of the sandstone. Also suggest graphically depicting bedding attitude in both the conglomerate and the phyllite, even though hypothetical.

No doubt I have not taken the time to make clear the reason for some of the suggestions. Possibly there will be an opportunity to discuss some of the points before the paper is ready for submission to the publisher.

J. H. Courtright

J. H. COURTRIGHT

JHC/kw

J. H. C.

JUN 17 1966

L. P. E.

JUN 17 1966

MR. ~~[illegible]~~ WES

READ AND RETURN

PREPARE ANSWERS ____ HANDLE

FILE ✓ INITIALS

Air Mail

June 15, 1966

Mr. Spencer R. Titley
Associate Professor
The University of Arizona
Tucson, Arizona 85721

W.E.S.

JUL 13 1966

Dear Spence:

It was nice to receive your letter of May 25 but I am unhappy about it because I have to throw a little cold water.

Nationalistic feelings in many Latin American countries have been increasing. This means that operation of existing large mines requires walking the tightrope of Latin politics. Bringing in a big new mine is even trickier. In these circumstances, I think you will find that most managements will take the position that the less published the better about any mineral property even though these papers would be in the strictly scientific category as you plan.

Your whole idea is commendable from the standpoint of science. Therefore, I believe you should have a try. You are correct in assuming that you should first get Anaconda's approval. Vin Perry is the man to start with here in New York. Next, you should try Harry Burgess in charge of Exploration for Kennecott, also here in New York.

As far as American Smelting is concerned, I'm afraid we would get a cool reception to publication of any material on Cuajone (under engineering investigation at the present time), Quellaveco (undeveloped), Toquepala (already published by Mr. Courtright and me although a good deal has been learned since that paper) and Michiquillay (under engineering study). I have not checked with officials here to determine what their policy might be and I will not do so until you let me know how you make out with Perry and Burgess. Without their cooperation, there is no point in even starting.

I hope the foregoing doesn't discourage you too much but I am merely trying to give you my views on the troubles you may encounter.

Yours very truly,

Kenyon Richard

CC-JHCourtright with attachments

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF MINES
DEPARTMENT OF GEOLOGY

RECEIVED
JUN 14 1966
K. RICHARD

May 25, 1966

Mr. Kenyon E. Richard
Chief Geologist
American Smelting and Refining Company
120 Broadway
New York City, New York 10005

Dear Kenyon,

The subject of this letter may come as a bit of a surprise to you but in considering what I want to do, your knowledge and close familiarization with the problems come to mind. So--this letter.

The Porphyry Copper volume is now being printed and will, hopefully, be distributed mid-June. Advanced sales and interest in this thing have surpassed my most optimistic expectations. Speaking frankly, I believe that the volume is a good one and one of potentially world-wide distribution. Also, frankly, I was really sick of the whole deal by the time it went to press. But I've forgotten all of that now and am off tilting at other windmills. Incidentally, any royalties that accrue will be used (after recovering a bit of my own personal expense) to set up a scholarship here in Eldred Wilson's name.

At any rate, here I go again. I would like to do a similar thing to the South American Porphyry Copper Deposits. This time (in contrast to the first time) I have a definite commitment from the Press (U. of A.) to publish such a thing. Up to this point, I've carried out no ground work. I am simply not familiar enough with the problems to proceed full steam ahead. However, I believe I can do it if the conditions of the first volume are met.

There were some problems on the first volume that carry over to the one I am proposing. The chief one is Anaconda. While

I had a commitment from Perry for papers on Yerrington and Cananea, I ultimately got only one through personal persuasion with Ruben Velasco--but nothing from Yerrington. I don't think it was so much uncooperation as it was indifference on the part of some of the Anaconda Persons in the Western U. S. with whom I had to work. Anyhow, this would be a major factor in the South American volume. An unknown to me here is the way in which Anaconda might view their information on operating properties down there, and further who I could work through on such a project. Any ideas?

I think the main thing here, if you care to give it is your impression of this project and potential people in New York with the various companies that would be sympathetic to the project and provide some high-level backing to the principle of the thing. If I can't get Anaconda, there is no real reason to go further. So far as the backing is concerned, I would ask nothing more than their agreement to cooperate with papers. You can see the need to reach the proper people in the proper way first. After that, I can take care of it.

As I view the proposed book, it would be much the same as the S. W. Porphyry book with a section on general matters and one on deposit descriptions. I hope to be able to use the present volume as fuel to get some money from an interested "sugar-daddy" to send me to So. America for a month or two next winter. I will have to do this if I am to be any good at the editing of this thing. However, I'm going to have to await publication and assimilation of the first book before feeling justified in requesting money of anyone--anyhow, I'll get down there.

Pending your comments and ideas, I thought I would get letters of request for papers out this summer and, hopefully, a year or year-and-a-half from now have something going.

I'd sure appreciate any and all comments, criticisms, and ideas you may have, together with any addresses of people, suggested authors, etc. that might occur to you. I would not anticipate making any money on this--royalties would go for scholarships--but am doing it for the joy and agony of the work.

Hope to hear from you when you get a minute or two off.--
Thanx for your help.

Very best regards,

Spence

Spencer R. Titley
Associate Professor

SRT:ac

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN EXPLORATION DEPARTMENT
P. O. BOX 5795, TUCSON, ARIZONA 85703

J. H. COURTRIGHT
CHIEF GEOLOGIST
L. P. ENTWISTLE
ASSISTANT CHIEF GEOLOGIST
W. E. SAEGART
ASSISTANT CHIEF GEOLOGIST

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

May 18, 1966

Mr. W. R. Landwehr
2382 Branner Drive
Menlo Park, California 94026

Dear Walt:

This will acknowledge your letter of April 8 with a copy of your paper on Mineral Belts, Mineral Districts and Regional Exploration in the Western United States.

I find it difficult to offer even a halfway intelligent comment on such a monumental piece of research and study. I am sure your paper will be a substantial contribution in the field of economic geology, backed up by a painstaking search of the literature plus a lifetime in the exploration business. I do not believe that there is any question but that it will be widely read and recognized as an important concept in metal exploration.

The principal suggestion that I have to offer is in regard to the broad belt of Tertiary and older intrusives that extends from Alaska to the tip of South America. In the Southwest, at any rate, the intrusive pattern trends north-northwest, and mineralization appears to be localized where the northeast belts intersect the intrusive trend. Possibly more emphasis should be placed on the role of the intrusives in this respect.

I don't believe you've listed Bronson Stringham in the references, possibly for good reasons. At any rate, he wrote a paper on productive and non-productive intrusives, Economic Geology, December, 1960, Volume 55, No. 8.

Following is a list of minor points:

Page 11: Information from various sources indicate that Tyrone consists of over 400 million tons of open pit ore averaging .7% Cu. Copper is present mainly as chalcocite and chalcopyrite. It is definitely economic at 34¢ copper, but presumably Phelps Dodge has, for the present anyway, ample sources of lower cost copper.

Page 13: All men who have done work subsequent to that of Lasky regard the volcanics of southwestern New Mexico as Early Tertiary; that is, the volcanics unconformably overlie Upper Cretaceous beds.

Page 15: No doubt this is merely an oversight, as you have noted the Pre-Cretaceous age of the intrusives in the second paragraph.

Page 16: A substantial area of disseminated copper mineralization occurs in porphyry and schist north of the Dividend Fault. Farther north it disappears under the Glance Conglomerate. The area has been incompletely drilled, but in all probability will be mined open pit at some future date.

Page 27: If Anderson stated that the Bagdad deposit is not truly disseminated, I believe he is in error as our studies of the deposits indicate it to be essentially equivalent to Silver Bell and other porphyry coppers of the Southwest in that the sulfides occur as narrow stringers and discrete grains between the stringers. Both stringers and discrete grains, I believe, should be regarded as disseminated mineralization.

Page 55: At Butte, discrete grains of copper permeate the rock between the veins. Although Butte geologists generallywill refuse to acknowledge it, Butte is definitely a porphyry copper deposit, differing only from other deposits by the fact that its veins are exceptionally wide and rich. In fact, Butte may prove to be the largest porphyry copper deposit in the West.

Page 104: John Kinnison comments: Late Tertiary (if this means Miocene, or younger) has no significant metallic ore deposits. Cripple Creek may be an exception.

Page 140: "Mount Davidson stock of diorite which is Miocene in age....." I believe Gianella regarded the Miocene lavas (Kate Peak andesite) as later than the veins at Virginia City. (Incidentally, in your list of references, it reads "Silver City".) I cannot determine this positively since we apparently do not have a copy in our library.

Page 142: You have noted that mineralization is confined to the Montana belt and is associated with intrusives; that is, the mineralization does not continue outside of the belt, even though the intrusives do. This is a significant observation.

Page 162: I am not sure just what you mean by Late Tertiary but at least at Virginia City I think it should be Middle Tertiary.

Page 174: Again under productive and barren centers of intrusion, it might be worth checking Bronson Stringham's paper.

Page 204: At the bottom of the page, I suggest including intrusives as another observable factor.

Page 217: Might not the disturbance of uplift of rock formations associated with intrusion be a factor in exposure of centers of mineralization by erosion:

Page 222: Again, is it not possible that disturbance by intrusive activity could be a factor?

	1966	1967-8
Mission	20,000	27,000
Pima	18,000	30,000
Duval Esp.	12,000	12,000
	50	69,000

Page 239: At the present time the combined daily production of Pima, Mission and Esperanza amounts to 50,000 tons per day. Pima and Mission are in the process of expanding, and by next year the total will be over 60,000 tpd. — probably near 70,000 tpd

Page 240: I presume you excluded San Manuel because the drilling started over 20 years ago; however, the drilling continued and was just being completed in 1948 when I first came to Arizona.

Page 243: In addition to underground workings, the Esperanza zone was explored by three different drill programs prior to Duval, the first being around 1912.

Page 245: Banner explored the old workings at Twin Buttes and followed copper mineralization in tactite on one of the underground levels out to the east under the gravels. Later they cut ore grade copper in some of their drill holes put down through the gravels.

Page 246: ".....but the final and most determinative will be on foot." I agree, except for the Canadian shield where sulfides underlie thin cover. Down here, many companies, including ASARCO, are still spending a lot of effort on I. P. work without success.

Page 247: We are besieged with air photo interpretation experts. This is a proven technique in oil, but bedding attitudes and post-mineral faults don't mean much, I think, in metal exploration.

Incidentally, we promoted some reconnaissance by helicopter early this year and have started systematic scrutiny of selected areas. This is pure prospecting of the "pick and pan" type, but with very modern (and expensive) transportation.

In closing, I believe the editors will find that your paper reads smoothly and that the conclusions are logically drawn. The opportunity for preview is much appreciated.

My best regards to you and La Rita,

J. H. Courtright

HAROLD COURTRIGHT

1. p 27 — Bagdad not a "true disseminated deposit" etc. Why pick out Bagdad for this note. Science would be served by referring to all porphyry Cu deposits as diss. in aggregate, including veinlets plus discrete grains.

2. p 89 Not all deposits (por Cu) have NE intrusive alignment. Eg - Silver Bell intrusive complex generally NW; Santa Rita Altar - Patagonia complex also NW.

3. p 96 Coeur D Alene Seems a poor description. What about Polaris fault zone? - trends W.

4. 101 "Nevadanic" is convenient as used here, but seems a poor practice to coin words this way. ~~What~~ How about "Mesozoic" qualified to extend into Eocene?

5. p110 At Sacaton we do not know fissure trends. NE a good assumption, and alt zone is NE. The same applies for Poston Butte.

6. p104 Late T (if this means Miocene and younger) have no significant ore deposits. Cripple Creek may be exception.

7. p118 – Minor point. Hg at Cu Basin only assumed by some to be late T.

8. p119 – Goldfield – Searls reports the veins overlain by Miocene? "Seebert Tuffs" (Esmeralda fm aquar) Believe this statement contained in Nevada Bur Mines Bull, Ferguson. Original ages based on deduction, for when Ransome? wrote on it (Prof paper) no veins known in the Tuffs and no expl. beneath them.

9. P 139 and other pages. Not all Volcanics in Nevada are Late T. Suggest careful consideration of pre and post-Esmeralda fm volcanics. Reference Ferguson 1936.

10. p140 GSA Cordill. Sect. 1958. Gianella postulates, as I recall, a pre-Miocene age for Comstock.

11. p240 – On Expl. uses: Negative theories dangerous. Positive theories useful in establishing priority of recon.

12. p242 Earlier ref. to Pima might be used (Thurmond, Heinrichs – AIME 1954?)

J. H. C.

APR 11 1966

Menlo Park
April 8, 1966

Dear Harold:

I am forewarding my splurge, which is the result of research into the district and regional distribution of major mineralization in western United States. It is rather long, for in the first chapter are district descriptions that are superfluous to anyone having a general knowledge of the ore deposits of the region. However, while I was gathering data on the mineralizing fissures, I also took notes on the geology of the districts, then summarized that information as a background for the trend charts.

You will also note that no page ends with a split paragraph, which accounts for the excess number of pages. Thats they way that a manuscript is supposed to be prepared, so I did it. When I prepare the manuscripts for the final papers, all I need are new introductions.

I plan to attempt separate papers covering "Belts of Major Mineralization" (the first four chapters), one on "Distribution of Major Mineralization in Western United States", and the third on "Regional Exploration". Perhaps I can get someone to publish them.

When I first started the research, I had in mind trying to discover areas that were interesting from an exploration standpoint; and also more about the reason why the mineralizing fissures in so many major districts trend northeasterly, for I though it might have some significance. However, I soon senged that perhaps I had stumbled upon something new, both scientifically and from the standpoint of exploration, so lost all interest in trying to find a mine, and concentrated upon the northeast trend.

The whole study has been rather fascinating, for I soon realized that much more was evolving than I had anticipated, and all the pieces seemed to fit into a logical whole. The result has been new concepts of the origin of centers of major mineralization, and their distribution, that to me seem important both scientifically and practically.

From a practical standpoint the new concepts are encouraging for regional exploration, for they indicate that there are many more major centers to be discovered, in all of the North American continent; and furnish a firmer scientific background upon which to base a comprehensive policy of regional exploration in all of the continent.

The belts, and terrane, explain the locations of a number of districts that have always seemed anomalous to me. For example, it has always been a mystery to me why the prairie country of South Dakota should contain the Black Hills district, isolated as ~~they are~~ it is from all other major mining districts. Nor why, in the potatoe country of Idaho not far from Boise, there should be the Silver City district; and in the center of the Columbia River Basalt Plateau of Miocene and later ages, there should be the highly productive gold area of the Blue Mountains of northeastern Oregon. And I have always wondered why the Mother Lode and Foothills Copper Belt of California are where they are, rather than somewhere else along the Sierra Nevada batholith -with which they are attributed to be genetically related - where apparently identical geologic conditions prevail. The concept of belts of mineralization explains all these apparent anomalies quite logically.

Four or five years ago the Tittmanns called on us. At that time I was just getting an inkling of the belts of major mineralization, and spent some time in explaining to Ed what I thought might develop from the studies, and the importance of the belts in regional exploration if the thing developed as I suspected. He seemed to grasp the idea, and was going to try to do something about it when he returned to New York - not from Asarco's standpoint, but in the matter of interesting other capital. However, just after that the company went into the travail of the big organization, Ed became Chairman, and apparently forgot or lost interest, for I have heard nothing from him.

I will be interested in your frank opinion of my ideas, if you find time to read the tome. I will probably want it returne for I will use it in preparing the three papers that I mentioned, but will write you when the time comes.

Our best regards to both of you.

Sincerely

Walt

JRC — Personal

January 25, 1966

Mr. Richard L. Hauger
Geochronology Laboratories
The University of Arizona
Tucson, Arizona 85721

Dear Mr. Hauger:

This will acknowledge with thanks a copy of the Annual Progress Report to AEC transmitted by your letter of August 5. Also acknowledged is your letter of August 18 asking for comment on Appendix 12 of the AEC Report. This is a somewhat belated reply, but other matters prevented my taking care of it earlier.

First, I should say that this study of Laramide intrusives in associated copper mineralization is certainly a worthwhile project and should be of prime interest to those engaged in the search for metals as well as those in science.

I can readily accept the thesis in general as to the close association of Laramide igneous activity and copper metallogenesis (convincingly demonstrated by the histogram, page A-XII-19) but object strenuously to the classification of any part of porphyry copper mineralization as magmatic. Although not prepared to argue the validity of the statement (page A-XII-1, paragraph 2) "Experimental evidence is given to show that under magmatic .....no workable mechanism for simultaneously removing lime and fixing potash in an igneous rock undergoing alteration", I wish to call your attention to compelling field evidence against a magmatic origin for the copper (and iron) sulfide deposits.

This evidence is simply the fact that in the field, pervasive alteration and sulfide mineralization form distinct zones which in places are sharply discordant with the intrusive pattern. Essentially all pre-mineral rock formations, Laramide and older intrusives, sediments, volcanics, and Precambrian schist, are altered and mineralized. But outside the zone, all rock, including the Laramide intrusives, is unaltered and unmineralized. Thus, a <u>close</u> spatial relationship does not appear to exist. That is, alteration-mineralization, controlled by some deep-seated zone of structural weakness, occurred as a separate and later event.

There are few illustrations to be found in the literature simply because relatively few alteration zones have been mapped. An excellent

illustration of the lack of this close spaced relationship occurs at Ely, Nevada. Here, as at Silver Bell, a long, relatively narrow zone of mineralization-alteration cuts sharply across irregular stock-like bodies of monzonite. Papers on both districts are scheduled to appear in the Wilson volume. To further emphasize the point I am trying to make, I have plotted the outline of the zone of alteration-mineralization on the enclosed geologic map of Silver Bell.

The largest mass of monzonite lies west of the Oxide pit, just outside the southwest edge of the zone of alteration-mineralization. However, note the tongues of monzonite extending into the zone, and farther north note the irregular dike-like monzonite bodies that cross the margin of the zone. Clearly, the alteration-mineralization has been superimposed on a pre-existing intrusive pattern.

In the vicinity of the Oxide pit and northwestward for several thousand feet, the zone appears to be in part confined to the limits of the alaskite intrusive, but south and west of the El Tiro pit mineralization-alteration dies out several thousand feet short of the edge of the alaskite mass.

Yours very truly,

J. H. COURTRIGHT

JHC/kw
Enclosure
cc: Paul Damon
J. E. Kinnison

P. S. Also, thank you for the copy of Bikerman's <u>Geological and Geochemical Studies of the Roskruge Range, Pima County, Arizona</u>.

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY
Water Resources Division
Rm. 327, Washington Bldg.
Arlington Towers
Arlington, Virginia 22209

J. H. C.

W.E.S. NOV 30 1965

DEC 17 1965

November 26, 1965

ER Nov 30
MR. JEK, WES
READ AND RETURN
PREPARE ANSWERS HANDLE
FILE INITIALS

Mr. J. H. Courtright
American Smelting and Refining Company
Valley National Bank Building
Tucson, Arizona

Dear Harold:

Enclosed are two copies of my paper on "Mesozoic formations in the Comobabi and Roskruge Mountains"--one for you and one for Johnnie Kinnison. The two of you will be able to gnash your teeth and chop lots of holes in what I've done, but at least as of this time it seems to be the best synthesis I could pull together.

Recently I had an opportunity to spend four days in Iceland. I flew over the new island of Surtsey and looked over some of the table mountains to which the Icelanders ascribe a subglacial origin. From a distance the Icelandic table mountains look much like some of the ranges in southern Arizona, but in detail, I believe the subglacial origin described by the Icelanders can be validated. The thing that struck me is that we may not have considered sufficiently the possibility of sub-aqueous origin for some of the deposits of the Claflin and Silverbell Formations.

Best regards.

Sincerely yours,

Leo

L. A. Heindl

Enclosures

what is this? Leo & I never discussed this term, to my the best of my recollection.
JEK

I would like to present of few features of leaching and enrichment as observed in the field ~~which~~ these do not require any particular knowledge of chemistry whatsoever — you all now should understand how oxidation and solution of copper take place — Understanding these features requires essentially no knowledge of chemistry

AGS MEETING 12/14/65

This will be a brief discussion of the leaching-enrichment history in some well known porphyry copper deposits.

As far back as 1904, Lindgren theorized that the Morenci chalcocite blanket originally formed about an ancient water table several hundred feet above its present position, and that subsequent erosion of Chase Creek Canyon exposed primary sulphides, leaving the chalcocite blanket stranded high above the Canyon bottom. Thus, the chalcocite is now undergoing leaching but not enrichment. That is, the copper in solution moves downward below the existing blanket. In his first paper on Mineral Park, Harrison Schmitt made similar observations.

The history of leaching and enrichment appears to span a substantial portion of the Tertiary Period, as indicated by age dates of volcanic flows near Silver Bell. Paul Damon and associates ~~have~~ assigned an age of 28 million years to a flow overlying conglomerate containing fragments derived by erosion from the SB zone of alteration-mineralization. These fragments contain cavities occupied by pre-existing sulphides, but the enclosing mud matrix is free of iron stain such as commonly found in ferruginous conglomerates formed by erosion of sulphide bearing rock. Thus, the evidence indicates that leaching and possibly enrichment preceded deposition of ~~the~~ this conglomerate at Silver Bell.

Similar conclusions may be drawn from the occurrence of altered and leached porphyry boulders in the Lower Cretaceous Glance conglomerate at Bisbee where the mud matrix appears free of iron stain. ~~that is~~ "Chalcocite boulders"

As in many porphyry copper deposits of the Southwest, the chalcocite blankets at Silver Bell exhibit conformance to modern topography. It is

suggested that the shape of the blanket is due to modification of a pre-existing, flat lying accumulation of chalcocite, the deposition of which was controlled by a relatively stable water table beneath a relatively mature land surface dating back possibly to Middle Tertiary time. In relatively recent times uplift and erosion affected reshaping of the blanket to follow the surface profile. This would require a wet climate as compared to that of today. Subsequently, renewed uplift of the mountains and decreased rainfall caused the water table to drop to a relatively low elevation --- leaving most of the chalcocite zone in an oxidizing environment.

.....Refer to El Tiro Section....for scale consider the, etc.... Point out leached zone etc.

although shown as a smoothly undulating line, the upper surface of the chalcocite zone, is, in detail, very irregular, or saw toothed in appearance --- caused by sharply defined penetrations of oxidation along faults and fractures. Obviously there is general conformance between the surface profile and the blanket of enrichment. The precise position of the water table is not known, however, only the deeper churn drill holes encountered water-----

This is simply a guess at the hypothetical position of the ancient blanket formed under a mature land surface----

At Toquepala, Peru, we have an example of a chalcocite blanket, roughly horizontal, lying beneath a surface of considerable relief. The water table was encountered a short distance below the canyon bottom. Little is known of its position elsewhere as most holes were bottomed without reaching water.

moly in bx pipe

(Point out zone of oxidation, deep primary, protore and limits of mineralization-alteration) Scale: 6000' across - capping up to 1000' - capping contains .10% cu - but -

During mapping of the surface we found that limonite after chalcocite (essentially Hematite) was concentrated in a layer several hundred feet above the Canyon bottom. Similar conditions were observed at Quellaveco, another porphyry copper deposit situated a few miles to the north. It is theorized that this high lying horizon was the position of an early chalcocite blanket found beneath a mature land surface. Uplift of the Andes caused a drastic lowering of the water table and accumulation of chalcocite near its existing position. However, underground workings and later, open pit mining have shown that at least the upper part of the zone is not in a stable environment, being incised deeply by oxidation.

I should mention that all do not agree that a water table is required for the deposition of chalcocite. In the Survey Bulletin on Castle Dome by Peterson Gilbert and Quick, it is concluded that enrichment took place well above the water table, forming the Castle Dome ore body in relatively recent geologic time --- sometime subsequent to the removal by erosion of the dacite and the Gila Conglomerate, possibly Pliocene or early Pleistocene. (p. 122).

However "The miami-inspiration cc deposits were considered by Ransome and Peterson (PP 342) p 87 to have formed prior to the deposition of the dacite (assigned an age of 20 million yrs. by Paul Damon and associates)

In closing, I might add that for those particularly interested in leaching and enrichment, the Bulletin on Castle Dome and Peterson prof Paper 342 contain a wealth of data on the mined out deposits and those currently being mined. Such detailed inf. is not avail on most of the known enriched Por cop deposits. Thank you