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April 11, 1977

Mr. J.H. Courtright
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703

Porphyry Copper Symposium

Dear Mr. Courtright:

Attached please find a copy of Mr. O.R. Radislao's memorandum on the Porphyry Copper Symposium he attended in Tucson in January. Excellent!

Mr. Radislao briefly summarizes the symposium and discussions of the individual lecturers. Also, he commented on the symposium in general and the lecturers' presentations. His comments are interesting. Possibly, you would like to pass them on to Mr. Richard, so that they could be considered prior to the planning of the next symposium.

Very truly yours,

Burton Devere Jr.

BURTON J. DEVERE JR.

attachment.

cc: TCOsborne w/attachment.

BJD:jbj

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B. J. D.

March 14, 1977 MAR 21 1977

Memorandum for Mr. B.J. Devere Jr.

Porphyry Copper Symposium

The Porphyry Copper Symposium held in Tucson, Arizona, from January 25 to 29, 1977 was organized by the Porphyry Symposium Associates, a group of distinguished porphyry copper experts, composed of Messrs. K. Richard, J.D. Lowell, J. Guilbert, T. Mitchum and P. Eimon.

In attendance were some forty representatives from various exploration and mining companies in the U.S., Canada, Mexico and South Africa. I was the only Asian present. There were two observers from the Jet Propulsion Laboratory of Pasadena, California.

P. Eimon handled the introductory and the general background portion of the symposium; J. Guilbert discussed alteration zoning while J.D. Lowell lectured on settings and distribution of porphyry copper deposits. Leach cap interpretation was T. Mitchum's topic; breccia pipes were K. Richard's subject.

The first three days were devoted to lectures, discussions and examination of rock, mineral, breccia pipe, leached cap and alteration specimens. The remaining two days were spent on visits to the Silver Bell and the Esperanza-Sierrita mines in Arizona.

Just to give a general idea of what transpired during the symposium, I shall attempt to present a summary of the discussions by individual lecturers, including some of their personal opinions and comments.

1. Paul Eimon

Eimon traced the history of the discovery and development of porphyry copper deposits from 1906 to the present. He gave

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a round-up of the major producing porphyry copper mines and the bigger discoveries that are in various stages of development as well as those that have been shelved for some reasons. Tonnage and grade figures along with capital requirements to put the deposits into production were supplied. He quoted statistics dealing with distribution of porphyry copper deposits according to geologic types and geologic ages, the major copper provinces of the world and their percent distribution of the metal, median tonnages, grades and copper contents.

Briefly, he mentioned the sad plight of the copper industry, referring to excessive world inventory, depressed prices, galloping operating costs, etc. As a specific example, he mentioned the Cuajone project of Asarco which would require at least a $1.00 per pound copper price for the project to be barely profitable.

With most of the near-surface or outcropping porphyry copper deposits already discovered, the trend in exploration will be towards the more extensive use of geophysics and proper interpretation of available drill hole data. In-situ leaching, which is currently being developed by KCC in its Lone Star deposits in Arizona, is expected to assume greater importance in the near future in the case of deep-seated, very low-grade deposits.

Exploration of porphyry copper deposits in British Columbia is again on the upswing, while in Chile, SW Pacific and the Philippines, exploration is deemed moderately active. Excellent opportunities for discovery exist in Argentina, Panama, Puerto Rico, SW Pacific and the Philippines.

2. J. Guilbert

Guilbert discussed hydrothermal alteration envelopes of porphyry copper deposits, defined the various alteration halos and enumerated the characteristic mineral assemblages in each one and their respective chemistry. He explained variations in zoning patterns, field and microscopic methods of recognizing and differentiating secondary potash feldspar and biotite, kaolin, sericite, chlorite and montmorillonite. Techniques for taking photomicrographs of thin sections and making actual size reproductions of polished rock surfaces faithfully showing textures, structures, etc. by simple xerox methods were also discussed at length.

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Guilbert emphasized the need for more work and studies on geobarometry in regards to the zoning model of porphyry copper, further stating that research possibilities exist in alteration studies such as changes in sericite composition from outer to inner alteration assemblages.

In the realm of trace element studies the following may be of interest:

a. Zinc is generally depleted over copper zone;

b. High molybdenum concentrations coincide with copper zone itself;

c. Sr is universally deficient within copper zone; conversely, Rb is enriched.

Specimens of altered rocks obtained from several operating porphyry copper mines in Arizona representing varying degrees and types of hydrothermal alteration were shown to the participants after the lectures.

3. J.D. Lowell

Lowell's lecture dwelt on the global distribution of porphyry copper deposits, the characteristics of the different porphyry copper districts and their wall rock environments, structural control, indicated depths of erosion, effects of climatic variations and post-mineral history, and variations in size and grade between porphyry copper districts. Comparisons between porphyry copper and porphyry molybdenum deposits were also discussed.

Four deposits received particular attention during his lecture, namely: the New Jersey ore body, Highland Valley, B.C., the Morenci deposit in Arizona, the Marcopper deposit in the Philippines and the El Salvador deposit in Chile.

An exhibition of color slides of several large copper mines and well-known deposits in South America such as Chuquicamata, El Teniente, Pachon, El Abra, Toquepala, Los Pelambres, Rio Blanco, etc. including Marcopper and the Casino deposit in the Yukon was the highlight of Lowell's lecture. The participants were also introduced to a large

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collection of rock specimens taken from the more well known porphyry copper deposits around the world. A number of specimens were from BCI's Tawi-Tawi deposit.

4. T. Mitchum

Mitchum grappled with leached cap interpretation, particularly, the significance of textures, colors and types of limonite as guides to secondary copper enrichment at depth. He explained the implications of the percentage of jarosite, goethite and hematite present in the capping. In general, the presence of hematite is positive indication that chalcocite or covellite was in the system. The hematite should have "relief", however, to suggest hematite after chalcocite or covellite, otherwise the hematite may just be after specularite or other iron mineral. ! ?

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The difference between pitch limonite and relief or live limonite were discussed as well as the significance of the presence of oxidation products in the leached cap in regards to Ph conditions.

As part of his lecture, Mitchum showed leached cap specimens, illustrating the various kinds of limonite, jarosite, goethite and hematite, and the so-called pitch limonite and relief limonite. He also demonstrated a copper test for manganese-copper stains and encrustations common in leached cappings.

A 3" x 4" laminated color chart was distributed among the participants for use in accurately estimating the percentages of jarosite, goethite and hematite composing the limonite present in the capping.

5. K. Richard

Breccia pipes, their origin and characteristics were the main theme of Richard's lecture. He gave examples of large breccia pipes which are ore deposits themselves such as Cananea in Mexico and Toquepala in Peru.

Inasmuch as Mission Exploration may probably explore a breccia pipe occurrence (the Mount Linao prospect) in the near future, it may be worthwhile mentioning here some of the features and characteristics of breccia pipes.

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The clasts in a breccia pipe are formed by mechanical breaking which are subsequently rotated. The clasts are usually of the same rock type but mixing of rock types is quite common. They come in various shapes, dikes, pipes, lenses, but most often are vertical, tube-like bodies with diameters of from 10 to 6000 feet. Breccia pipes generally occur in large porphyry copper deposits. Although they are good channels for hydrothermal fluids, they are not always ore-bearing, and hypogene zoning is unusual. Breccia pipes are often obscure in outcrops or underground. Most important of all, they tend to occur in the upper portion of porphyry copper systems.

Richard elucidated the mechanics of diatreme formation. He noted that fluidized breccia or pebble dikes are formed late in the mineralizing process, are usually compact and hence are not susceptible to metallization.

In drilling porphyry copper deposits, Richard is unequivocal in his preference for vertical holes, his contention being that vertical holes yield higher core recoveries than angle holes, all things considered.

After the lecture, the participants were shown a large collection of breccia pipe specimens from various mines and prospects notably those in Mexico and South America.

The most eagerly awaited, interesting and truly beneficial part of the symposium were the visits to Duval Corporation's Esperanza-Sierrita mine and Asarco's Silver Bell mine, both in Arizona. These visits afforded the participants a unique opportunity to get personally acquainted with some of the better known porphyry copper deposits in this part of the world, and to learn on the spot about their geology, structural setting, alteration, mineralization and a myriad other things. My exposure to leached cappings, supergene enrichment blankets, alteration assemblages and breccia pipes immeasurably increased my understanding of such important features of porphyry coppers.

While the symposium may be said to have achieved its purpose and may be deemed successful, a few things about it deserve comments.

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As regards the lecturers themselves, there is no doubt as to their knowledge of porphyry copper and the range of their experiences. It was in the preparation and presentation that some speakers were less effective than the others. Eimon and Mitchum were given to digressions and showed a propensity to be vague with their data. Mitchum was worse of the two, being the least prepared. His lack of preparation was compounded by his tendency to stutter. Guilbert was an accomplished lecturer, sure of his facts. So was Lowell. The most witty and scintillating speaker of them all, however, was Richard who captivated his listeners with his charming jokes and funny stories. Richard was also the most knowledgeable and experienced, the other speakers calling upon him to confirm their information and getting his opinion from time to time.

The introductory part of Eimon could well be scrapped or greatly improved. Instead of supplying voluminous statistics that were promptly forgotten anyway, he could have been better off discussing geochemistry, trace element studies, fluid inclusions or lineament interpretations.

Since the participants in the symposium come from various parts of the world, bringing with them knowledge and experience gained in their respective areas, audience participation at these symposiums should be encouraged. In this way the discussions could be made livelier, informative and wide-ranging.

The mine visits being the most valuable part of the symposium, more of these should be arranged for the greater benefit of the participants.

O'Donnell R. Radislao

O'DONNELL R. RADISLAO

ORR:jbj