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James Doyle Sell Mining Collection

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ASARCO

Work File

Exploration Department
R. L. Brown
Assistant Director of Exploration

J. H. C.

MAR 7 - 1977

March 4, 1977

RECEIVED
MAR 7 - 1977
EXPLORATION DEPT.

Mr. J. H. Courtright
Tucson Office

Dear Mr. Courtright:

Thank you for my copy of your memorandum dated December 27 in which you discuss various papers given at the Arizona Branch meeting of the AIME.

I am sorry you did not ask Mr. Quinlan what mine managers would give for a geologist who is both lucky and brilliant, or if he considered these two attributes were mutually exclusive.

Dr. A. V. Heyl appears to be more confident in the spacial geometry between related sphalerite and flourite mineralization than our people are. As you know, Del Harper has been mapping barite-flourite-sphalerite interfaces where he can, and while he does show that all these minerals do occur in some pattern near deposits, he has in no case demonstrated circular classic zoning pattersn. Perhaps one of the more important but unmentioned features of the Elmwood area are the very small and discontinous veinlets which extend from the deposits to overlying rocks and in cases to the surface. Mr. Callahan never mentions this feature in his discussion of the initial New Jersey Zinc work at Carthage but these veinlets are thought by some outsiders to have been important in his decision to explore the area.

As there was a reference to the copper ore at Mt. Isa in your memo, I might also report that the young Turks at Mt. Isa are now suggesting an epigenetic origin for the copper ore. They consider that these deposits, which as you know are coincident with the silica dolomite, were caused by the injection under great pressure of silica-copper-water solutions into the Urquhart and that this pressure caused some kind of implosive activity which resulted in the breaking up of the shale into the fragments you will remember seeing. The lowering of temperature-pressure after the implosion changed temperature pressure conditions and allowed the precipitation of the copper.

Possible but impractical Theory! There is no mixing of the unquestionable syngenetic zinc and copper ore. JHC

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Of course, all of the above is far from being music in Tim Bennett's ears, but the young geologists at Mt. Isa do not appear to me to be making any effort to accommodate his sygenetic theories.

Very truly yours,

R. L. Brown

R. L. Brown

ASARCO

Exploration Department

December 27th, 1976.

FILE MEMORANDUM

AIME - ARIZONA MEETING
December 6th, 1976.

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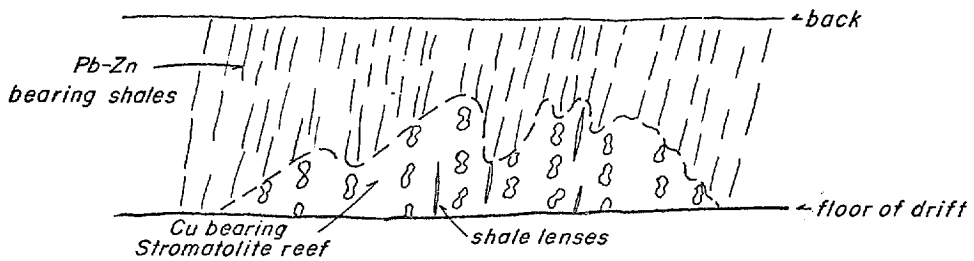

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c.c. T.C.Osborne
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by A. V. Heyl

U.S. Geological Survey, Denver, Colorado 80225

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The main components of the hydrothermal (hot fluids) solutions which deposited the ores of the Mississippi Valley type were concentrated, Na, Ca, K Chloride brines, which were heated and mobilized from adjacent basins up into the crests and flanks of domes, uplifts, and into fault zones. The solutions were heated to temperatures of from 70-200°C by deep burial, by deep circulation or by magmatic heat provided from deep-seated alkalic magmas. In each district the saline brine solutions mingled with various quantities of other solutions prior to and during deposition, such as cool, dilute meteoric waters, local sulfate-bearing brines, and a small magmatic fraction in some districts. The magmatic contribution ranged from heat alone to heated differentiates containing some of the main ore-forming components such as fluorine, silver, rare earths, and several trace elements. Some components such as lead may have shallow crustal source, others are derived from the

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PALEOZOIC-MESOZOIC VOLCANOGENIC ORES OF CALIFORNIA AND NEVADA

Anthony Payne

In recent years, many mineral deposits enclosed within eugeosyncli rocks of California and western Nevada have been re-interpreted as olde pre-orogenic ore types. A number of sedimentary, volcanogenic, skarn, and hydrothermal (both vein and disseminated) ores are now known or suspected to pre-date the Jurassic-Cretaceous orogeny and the emplaceme of the Sierran Bathylith. There is particular interest in the commercially important volcanogenic pyritic copper ores found in mafic volcanic sequences of Ordovician to Cretaceous age. The pyritic copper deposits are often closely associated with rhyolitic pyroclastic units at the top of spilite-keratophyre sequences, as developed in the Foothill Copper Belt, Shasta Copper Belt, and elsewhere in the region. Devonian, Triassic, and Jurassic rocks appear to be particularly well mineralized with this ore type. The Big Mike deposit near Winnemucca is found within greenstone and clastics of the Carboniferous Pumpernick formation, and can be interpreted as volcanogenic. The Rio Tinto depos near Mountain City lies conformably within a greenstone tuff-clastic unit of the Ordovician Valmy formation, and may represent a volcanogenic exhalative-sedimentary lens. Bedded barite, found mainly in the volcan chert and quartzite of the Devonian Slaven formation now produces more than two-thirds of the domestic barite mined in the U.S. Of lesser economic importance are the strata-controlled manganese and iron deposits contained within Carboniferous to Cretaceous marine volcanic sequences, and a feeble copper-zeolite amygdaloidal mineralization observed in vesiculated flow tops and pillow surfaces of basalts and basaltic andesites of the Triassic and Jurassic. An unusual bedded silver-antimony ore (locally with scheelite) is of marginal economic interest and is found in quartz gangue conformably enclosed within sedimentary strata at the top of Permian volcanic sequences, as at Candelaria, and is suggestive of volcanogenesis. A number of factors have delayed the recognition of the volcanogenic character of these ore types. There is often a gradation from deposits showing obvious volcanic affinity to those showing no demonstrable connection with submarine eruptive centers. The variable effects of regional and thermal metamorphism obscure primary relationships. The structural complexity of the region, deep differential erosion during various epochs, and preponderance of young cover rock interferes with correlatio of older mineral occurrences. Many of the published mine descriptions, particularly with respect to the geology of the enclosing rocks at the smaller mines and prospects, are so incomplete as to necessitate fresh observations in the field.

Reno, Nevada
October 7, 1976

ORE-FORMING FLUIDS OF METAMORPHIC ORIGIN

by

Richard L. Nielsen
Kennecott Exploration, Inc.
2300 West 1700 South
Salt Lake City, Utah

ABSTRACT

Ore-forming fluids may be produced by dehydration metamorphic reactions, either along an active subduction zone or during progressive regional metamorphism of a thick sedimentary prism.

During active subduction, a descending slab of oceanic lithosphere, consisting of basalt and sediment cover with important amounts of water, S, Cl, F, and other metals, will undergo metamorphism and release fluids at a relatively shallow level (100 km ±) where amphibole, muscovite, talc, and serpentine decompose (Fyfe and McBirney, 1975). These fluids may produce greenschist, blue schist, zeolite facies metamorphism, and precious metal mineralization in rocks of the overlying plate (e.g., California Foothill gold, Juneau gold). At deeper levels (200 to 300 km) further metamorphism will break down phlogophite and release hydrothermal fluids relatively enriched in K, Cl, and F which, as they move upward out of the "heat sink" along the subduction into relatively hot rocks, can scavenge incompatible metals (K, Rb, Sn, Pb, U, Mo, Cu, and others) from the upper mantle (Best, 1975), produce calc-alkaline magma by partial melting of upper mantle or lower crustal rocks, or may ascend to the surface as primary ore-forming fluids along deep faults and tensional fractures in very active orogenic regions.

Hydrothermal solutions produced during regional metamorphism of crustal rocks are thought to have produced ore deposits of replacement copper (Mount Isa) and skarn-uranium (Mary Kathleen). Features that suggest some porphyry copper deposition may involve hydrothermal fluids of deep metamorphic origin include: (1) mineralization and alteration patterns strongly controlled by regional structures rather than igneous contacts (e.g., in some British Columbia and Philippines deposits), (2) crosscutting relationships and radiometric age dates which indicate the principal mineralization event is significantly younger than solidification and cooling of associated intrusive host rock (e.g., Butte and Yandera, P.N.G.), and (3) geochemical and fluid inclusion data that indicate hydrothermal fluids were not in chemical equilibrium and probably not derived by exsolution from adjacent igneous rocks (e.g., Ray, Arizona; Banks, 1976). The concept of deep metamorphic origin for ore fluids is an alternate hypothesis to the popular orthomagmatic model for porphyry copper formation.

The case for differention-derived magmatic waters in the ore-forming hydrothermal systems of porphyry copper deposits

S. C. Creasey

Synopsis

Among the group of stocks in a given porphyry copper mining district, the deposits are most closely associated in space and age to a relatively young, differentiated member of the group. This in itself suggests a relationship between differentiation and porphyry copper deposits.

Hydrothermal alteration products, fluid-inclusion compositions, and oxygen-deuterium compositions of hydrothermal alteration minerals are all consistent with the concept of a dominance of meteoric waters in the formation of propylitic and argillic alteration, a dominance of magmatic waters in formation of potassic alteration, and mixed waters in formation of sericitic alteration. Because primary porphyry copper metallization is mostly closely associated with potassic alteration and if potassic alteration is absent with sericitic alteration, magmatic waters seem critical to porphyry copper metallization, which is the product of highly saline brines, chiefly alkali brines, as suggested by fluid-inclusion data.

In the normal crystallization of a magma mafic minerals and plagioclase crystallize early and quartz and alkali feldspar late. If fractional crystallization occurs (differentiation), the residual magma is impoverished in Ca, Al, Fe, and Mg and enriched in K, Na, and Si. If through fractionation, there is insufficient Al to form K-feldspar, potassium silicate forms, and experimental work has shown that it has a continuous

solubility with water. Therefore, if a water-bearing magma undergoes fractionation, the expectable end product would be an aqueous fluid rich in alkali and silica. In this would be the halogens, sulfur, and metals, if these elements were relatively abundant in the original magma.

Field, laboratory, and experimental data all seem compatible with the concept of deriving some hydrothermal ore fluids through fractionation of a water-bearing magma rich in metals, sulfur, and halogens.

MAJOR AND TRACE ELEMENT VARIATIONS AROUND PORPHYRY DEPOSITS- WHAT DO THEY TELL US?

ABSTRACT

Rapid, accurate analytical methods are producing data concerning dispersion patterns, fluid competences and characteristics, alteration mechanisms, and genetic models of porphyry deposits that are both explorationally and scientifically useful. Whole rock major element data are now available for fresh and altered rocks from most North and South American districts, and trace element data have been released for San Manuel, Red Mountain, Sierrita, and 4 Metals, Arizona, Battle Mountain, Nevada, the Babine Lake and Highland Valley deposits, B.C., and the Henderson deposit, Colorado, with limited data available for other districts.

Uses to which the data can be put are discussed, with examples. Major element data describe mass action-gain loss relationships which in turn describe the alteration process, statically (as reaction products) and dynamically (in terms of enabling processes and reactions). They thereby define zoning, proscribe the nature of the hydrothermal fluid, establish petrogenetic links between rocks and orebodies, and set limits to the physical geochemistry of ore forming systems. Partitioning of Na and K between various phases (especially feldspars and micas) are geothermometric, and Mg, Al, and Si in micas may be geobarometric. K_2O,Na_2O and SiO_2 ratios of fresh rocks may indicate depth to the Benioff Zone. Although barren porphyries can not yet be discerned from productive ones by major element chemistry, barren stocks appear to plot distinctively (at deeper apparent crystallization levels) on Bowen's petrogenetic residuum.

Minor elements have been more used and more useful. K/Rb and Rb anomalies define patterns of hydrothermal activity, and identify the hydrothermal system. Rb/Sr can provide data on the direction of fluid flow. Sr levels are thought to provide depth measurement to Benioff Zones in South America, at least. The overall patterns of Cu-Mo and Pb-Zn serve to identify porphyry environments, Cu and Mo providing exploration targets significantly greater than the ore zone. Sulfur provides the largest target area consistently related to copper, with Zn showing most consistent zoning. Cu-As species appear late and high in porphyry ore deposit geometry. Surprisingly, trace elements do not yet distinguish barren from productive systems, but work is continuing. Different "pathfinder" elements other than Cu, Mo, Zn, and S - such as U, Sn, Ti, Co, Ni, Cr, Mn, and As - are variously used but their behavior is not universally consistent. Rare earth elements are becoming more useful as their behavior is clarified. Microanalytical procedures are permitting greater understanding of oreforming processes through study of fluid inclusion contents, and Cl and Cl/F areuseful geochemically and explorationally. Fe/Zn in sphalerite is geobarometric, with constraints.

Geochemical haloes can be expected to test models of genesis for particular deposits by comparison of element haloes with predicted flow lines of fluids. Dispersion haloes (positively anomalous patterns) appear more useful, and should conform to flowlines and streamlines; extraction haloes (negatively anomalous patterns, the "butterfly" effect) may not be compelling for spatial and statistical reasons.

10/13/76-ls

John M. Guilbert
Tucson, Arizona

A Classification of Some Hydrothermal Systems

S. A. Williams
Phelps Dodge Corporation

Detailed study of numerous mineralized occurrences leads to the conclusion that many types of metallization can be correlated with a certain intrusive type, characterisitic gangue and metallic minerals, and a distinctive suite of mobile elements. Conversely, the fact that such correlations exist is taken as evidence that metallization may be derived from certain intrusive rocks.

Data for 14 recognizable types of metallization will be presented. These include characteristics of the intrusive (or hypabyssal) rock thought to be responsible for metallization, alteration and gangue assemblages, elements present and their zoning patterns, and ore minerals.

JHC.

ASARCO

Exploration Department

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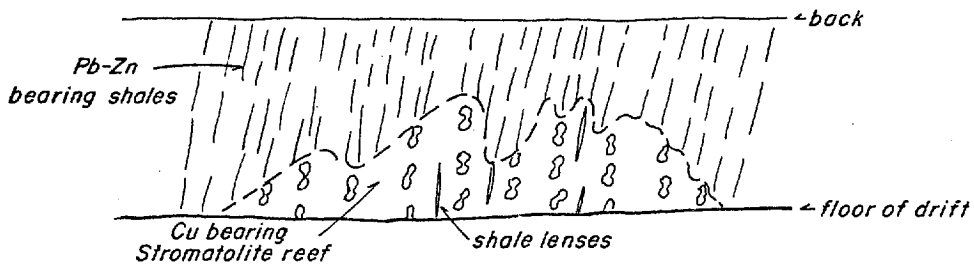

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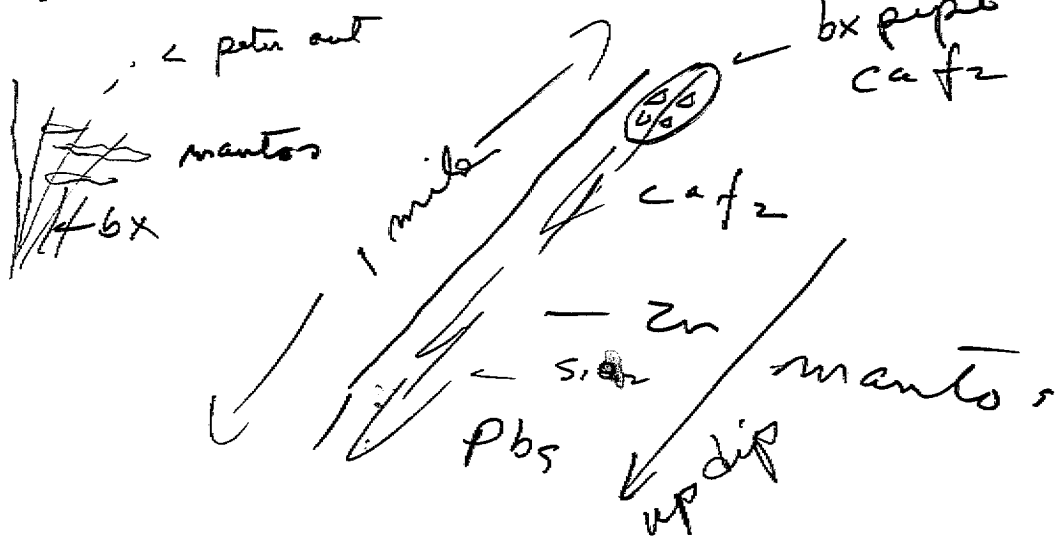
Heyl

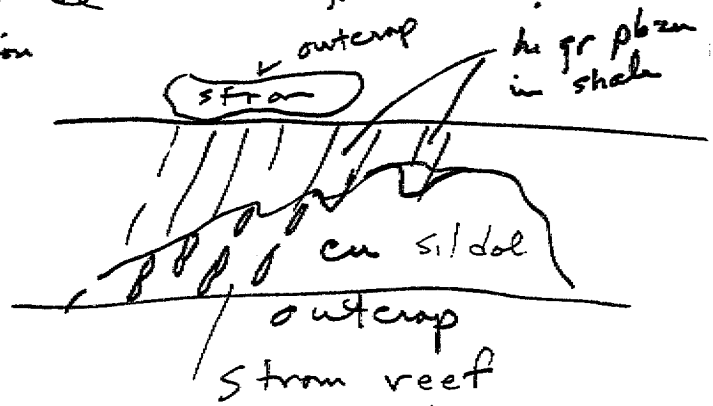
SE Illinois Fluorspar



Sid Williams – tourmaline – too common – no guide

Dick Nielsen – fault contact volc – shale (Cu) – not Isa

Pete Dunn – upper level – about to be closed off –
not Isa stromatolite – section



Heyl – normal leads in main part of deposit (Leadville)
J Pbs on fringes –
autallic? prominent in contrast to granite etc

Central K – CaF_2 in center – revers at Elmwood

RECEIVED OCT 11 1976

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Anthony Payne

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Reno, Nevada
October 7, 1976

John Guilbert — por cop aureoles — retrogenic
alteration products — (KR - chambour - Babine Lake - good)
- por cop 520 my - in So. Af. name? —
- calc alkaline rocks - por cop type —
barren and prod por — no def. criteria — barren
may have x'lized somewhat deeper —
— ~~pr~~ anomalous — 301 whole rock SW USA — not
comparable to Highland Valley —
Exploration — most reliable — Cu, S (pyrite), Zn (best element
as halo) —

Tony Payne - 17 yrs at Reno - Mackay
chromite magmatic deposits — older por cop
(copper foothill ?) pre Sierra Batholith.
- Volcanogenic ⟶ Russia - Bauxite —
in strata — eroded volcanoes — —
New - Devonian bedded barite —
may be sed — or may be volcanogenic
- (frags of barite) in beds — slump origin
- Tony ~~fav~~ favors volcanogenic
Big Mike - Mt City — vol - Nev

Foot hill cal — volcanogenic
Barite
Tuff
Pyrr
Upper Jurassic
Pyroclastic debris

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nevada — Bedded ag — candelaria
may be volcanogenic —
permo triassic

ORE-FORMING FLUIDS OF METAMORPHIC ORIGIN

by

Richard L. Nielsen
Kennecott Exploration, Inc.
2300 West 1700 South
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ABSTRACT

Ore-forming fluids may be produced by dehydration metamorphic reactions, either along an active subduction zone or during progressive regional metamorphism of a thick sedimentary prism.

During active subduction, a descending slab of oceanic lithosphere, consisting of basalt and sediment cover with important amounts of water, S, Cl, F, and other metals, will undergo metamorphism and release fluids at a relatively shallow level (100 km ±) where amphibole, muscovite, talc, and serpentine decompose (Fyfe and McBirney, 1975). These fluids may produce greenschist, blue schist, zeolite facies metamorphism, and precious metal mineralization in rocks of the overlying plate (e.g., California Foothill gold, Juneau gold). At deeper levels (200 to 300 km) further metamorphism will break down phlogophite and release hydrothermal fluids relatively enriched in K, Cl, and F which, as they move upward out of the "heat sink" along the subduction into relatively hot rocks, can scavenge incompatible metals (K, Rb, Sn, Pb, U, Mo, Cu, and others) from the upper mantle (Best, 1975), produce calc-alkaline magma by partial melting of upper mantle or lower crustal rocks, or may ascend to the surface as primary ore-forming fluids along deep faults and tensional fractures in very active orogenic regions.

Hydrothermal solutions produced during regional metamorphism of crustal rocks are thought to have produced ore deposits of replacement copper (Mount Isa) and skarn-uranium (Mary Kathleen). Features that suggest some porphyry copper deposition may involve hydrothermal fluids of deep metamorphic origin include: (1) mineralization and alteration patterns strongly controlled by regional structures rather than igneous contacts (e.g., in some British Columbia and Philippines deposits), (2) crosscutting relationships and radiometric age dates which indicate the principal mineralization event is significantly younger than solidification and cooling of associated intrusive host rock (e.g., Butte and Yandera, P.N.G.), and (3) geochemical and fluid inclusion data that indicate hydrothermal fluids were not in chemical equilibrium and probably not derived by exsolution from adjacent igneous rocks (e.g., Ray, Arizona; Banks, 1976). The concept of deep metamorphic origin for ore fluids is an alternate hypothesis to the popular orthomagmatic model for porphyry copper formation.

Al Heyl — presently in Black Range

miss val type —

SE miss — upper miss
on Cin arch central Tenn
+ one empl in pre lithified
rock — all have some fault
on fins control —
most on flanks — not many
in basin (all drilled for oil)
SE mo — one of largest Ag producer

solution dissolve / S — move
up fins time —
thinning accompanied thinning
of beds
90 — 200 C — solutions
basin brines — heated
then diluted by meteoric water
Ill Kentucky — Ag zoned concentrically also Pb, Cu.
SE mo — Zn rich in center
Co Ni in Pb and Zn

upper miss — pos ty to dep
hot spot — cop zone
trend. NNW across main dist

The case for differention-derived magmatic waters in the ore-forming hydrothermal systems of porphyry copper deposits

S. C. Creasey

Synopsis

Among the group of stocks in a given porphyry copper mining district, the deposits are most closely associated in space and age to a relatively young, differentiated member of the group. This in itself suggests a relationship between differentiation and porphyry copper deposits.

Hydrothermal alteration products, fluid-inclusion compositions, and oxygen-deuterium compositions of hydrothermal alteration minerals are all consistent with the concept of a dominance of meteoric waters in the formation of propylitic and argillic alteration, a dominance of magmatic waters in formation of potassic alteration, and mixed waters in formation of sericitic alteration. Because primary porphyry copper metallization is mostly closely associated with potassic alteration and if potassic alteration is absent with sericitic alteration, magmatic waters seem critical to porphyry copper metallization, which is the product of highly saline brines, chiefly alkali brines, as suggested by fluid-inclusion data.

In the normal crystallization of a magma mafic minerals and plagioclase crystallize early and quartz and alkali feldspar late. If fractional crystallization occurs (differentiation), the residual magma is impoverished in Ca, Al, Fe, and Mg and enriched in K, Na, and Si. If through fractionation, there is insufficient Al to form K-feldspar, potassium silicate forms, and experimental work has shown that it has a continuous

solubility with water. Therefore, if a water-bearing magma undergoes fractionation, the expectable end product would be an aqueous fluid rich in alkali and silica. In this would be the halogens, sulfur, and metals, if these elements were relatively abundant in the original magma.

Field, laboratory, and experimental data all seem compatible with the concept of deriving some hydrothermal ore fluids through fractionation of a water-bearing magma rich in metals, sulfur, and halogens.

RECEIVED OCT 18 1976

MAJOR AND TRACE ELEMENT VARIATIONS AROUND PORPHYRY DEPOSITS- WHAT DO THEY TELL US?

ABSTRACT

Rapid, accurate analytical methods are producing data concerning dispersion patterns, fluid competences and characteristics, alteration mechanisms, and genetic models of porphyry deposits that are both explorationally and scientifically useful. Whole rock major element data are now available for fresh and altered rocks from most North and South American districts, and trace element data have been released for San Manuel, Red Mountain, Sierrita, and 4 Metals, Arizona, Battle Mountain, Nevada, the Babine Lake and Highland Valley deposits, B.C., and the Henderson deposit, Colorado, with limited data available for other districts.

Uses to which the data can be put are discussed, with examples. Major element data describe mass action-gain loss relationships which in turn describe the alteration process, statically (as reaction products) and dynamically (in terms of enabling processes and reactions). They thereby define zoning, proscribe the nature of the hydrothermal fluid, establish petrogenetic links between rocks and orebodies, and set limits to the physical geochemistry of ore forming systems. Partitioning of Na and K between various phases (especially feldspars and micas) are geothermometric, and Mg, Al, and Si in micas may be geobarometric. K_2O,Na_2O and SiO_2 ratios of fresh rocks may indicate depth to the Benioff Zone. Although barren porphyries can not yet be discerned from productive ones by major element chemistry, barren stocks appear to plot distinctively (at deeper apparent crystallization levels) on Bowen's petrogenetic residuum.

Minor elements have been more used and more useful. K/Rb and Rb anomalies define patterns of hydrothermal activity, and identify the hydrothermal system. Rb/Sr can provide data on the direction of fluid flow. Sr levels are thought to provide depth measurement to Benioff Zones in South America, at least. The overall patterns of Cu-Mo and Pb-Zn serve to identify porphyry environments, Cu and Mo providing exploration targets significantly greater than the ore zone. Sulfur provides the largest target area consistently related to copper, with Zn showing most consistent zoning. Cu-As species appear late and high in porphyry ore deposit geometry. Surprisingly, trace elements do not yet distinguish barren from productive systems, but work is continuing. Different "pathfinder" elements other than Cu, Mo, Zn, and S - such as U, Sn, Ti, Co, Ni, Cr, Mn, and As - are variously used but their behavior is not universally consistent. Rare earth elements are becoming more useful as their behavior is clarified. Microanalytical procedures are permitting greater understanding of oreforming processes through study of fluid inclusion contents, and Cl and Cl/F areuseful geochemically and explorationally. Fe/Zn in sphalerite is geobarometric, with constraints.

Geochemical haloes can be expected to test models of genesis for particular deposits by comparison of element haloes with predicted flow lines of fluids. Dispersion haloes (positively anomalous patterns) appear more useful, and should conform to flowlines and streamlines; extraction haloes (negatively anomalous patterns, the "butterfly" effect) may not be compelling for spatial and statistical reasons.

10/13/76-ls

John M. Guilbert
Tucson, Arizona

A Classification of Some Hydrothermal Systems

S. A. Williams
Phelps Dodge Corporation

Detailed study of numerous mineralized occurrences leads to the conclusion that many types of metallization can be correlated with a certain intrusive type, characterisitic gangue and metallic minerals, and a distinctive suite of mobile elements. Conversely, the fact that such correlations exist is taken as evidence that metallization may be derived from certain intrusive rocks.

Data for 14 recognizable types of metallization will be presented. These include characteristics of the intrusive (or hypabyssal) rock thought to be responsible for metallization, alteration and gangue assemblages, elements present and their zoning patterns, and ore minerals.

Sid Williams — (1) qtz monz — New tungsten — beryl — pyrrhotite

/mineral (2) " " Ward nev — py cpy — gal — silic leaching

(3) " "

(4) — — Star Nev — orthoclase —

1 diabase Sylvanite N.M.

2 " Cobalt Ontario

3 Tonalite Radersburg mont

4 Tin por — Cerrito Bol — qtz latite

5 Moly por — Climax — K spar alt to Rhodocrosite

6 Copper por — — rutile — apatite growth

7. Basalt Cu — Michigan

8. Dacitic vulcanism —

9 — Andesite Sells Ariz —

10 — " Cerro Verde Nev mexico

S. Creasey — meteoric water — convection cells

— magmatic water — diff — produce late intru

Dick Nielsen — water released by metamor — are forming fluid

magmatic water not necess involved.

Sil dol [illegible]

smith ~~to~~ rock Cu leached from greenstone

Bug 38 — 36

Bathe 72 60

rock cooled to contain argon

mag some of fluids

diff to expl

Ray as diff of ore fluids

J. H. C.
NOV 30 1976

AIME - ARIZONA SECTION MEETING
December 5 & 6, 1976

MINING GEOLOGY DIVISION

"Ore-Forming Fluids and the Metals in Them"
Coconino Room - Tucson Community Center

Chairmen: J. J. Quinlan
Kerr-McGee Corporation
Patagonia, Arizona

mqr — rather have a lucky guy than a brilliant one!

W. P. Johnston
Hecla Mining Company
Reno, Nevada

MORNING SESSION
9:15 to 11:45 am

"A Classification of Some Hydrothermal Systems"
"Sid" S. A. Williams
Phelps Dodge Corporation, Douglas, Arizona

"The Case for Differention-Derived Magnetic Waters in the Ore-Forming Hydrothermal Systems of Porphyry Copper Deposits"
S. C. Creasey
U.S. Geological Survey, Menlo Park, California

"Ore-Forming Fluids of Metamorphic Origin"
Richard L. Nielsen
Kennecott Exploration, Inc., Salt Lake City, Utah

"Major and Trace Element Variations Around Porphyry Deposits - What Do They Tell Us?"
John M. Guilbert — to Butte 1957 - U of A 1965
University of Arizona, Tucson, Arizona

"Paleozoic-Mesozoic Volcanogenic Ores of California and Nevada"
Anthony Payne
Mackay School of Mines, University of Nevada, Reno, Nevada

"Solutions Which Deposited the Mississippi Valley Type Ores, U.S.A."
A. V. Heyl
U.S. Geological Survey, Denver, Colorado

AFTERNOON SESSION
2:00 to 4:30 pm

Panel and floor discussion on the "ORIGIN AND NATURE OF ORE-FORMING FLUIDS AND THE METALS IN THEM"

Panel to consist of participants in morning session. Discussion will be opened to the floor and we invite your participation and contributions.
"COME PREPARED"