DESCRIPTIVE MODEL OF PORPHYRY Cu

By Dennis P. Cox

DESCRIPTION This generalized model includes various subtypes all of which contain chalcopyrite in stockwork veinlets in hydrothermally altered porphry and adjacent country rock (see fig. 50).

GENERAL REFERENCE Titley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite or syenitic porphyry intruding granitic, volcanic, calcareous sedimentary, and other rocks.

Textures Porphyry has closely spaced phenocrysts and microaplitic quartz-feldspar groundmass.

Age Range Mainly Mesozoic and Cenozoic, but may be any age.

Depositional Environment High-level intrusive rocks contemporaneous with abundant dikes, breccia fipes, faults. Also cupolas of batholiths.

Tectonic Setting(s) Rift zones contemporaneous with Andean or island-arc volcanism along convergent plate boundaries. Uplift and erosion to expose subvolcanic rocks.

Associated Deposit Types Base-metal skarn, epithermal veins, polymetallic replacement, volcanic hosted massive replacement. See also: Porphyry Cu-skarn related, porphyry Cu-Mo, and porphyry Cu-Au.

DEPOSIT DESCRIPTION

Mineralogy: Chalcopyrite + pyrite ± molybdenite; chalcopyrite + magnetite ± bornite ± Au; assemblages may be superposed. Quartz + K-feldspar + biotite ± anhydrite; quartz + sericite + clay minerals. Late veins of enargite, tetrahedrite, galena, sphalerite, and barite in some deposits.

Texture/Structure Stockwork veinlets and disseminated sulfide grains.

Alteration From bottom, innermost zones outward: sodic-calcic, potassic, phyllic, and argillic to propylitic. High-alumina alteration in upper part of some deposits. See table 3. Propylitic or phyllic alteration may overprint early potassic assemblage.

Ore Controls Stockwork veins in porphyry, along porphyry contact, and in favorable country rocks such as carbonate rocks, mafic igneous rocks, and older granitic plutons.

Weathering Green and blue Cu carbonates and silicates in weathered outcrops, or where leaching is intense, barren outcrops remain after Cu is leached, transported downward, and deposited as secondary sulfides at water table or paleowater table. Fractures in leached outcrops are coated with hematitic limonite having bright red streak. Deposits of secondary sulfides contain chalcocite and other Cu_2S minerals replacing pyrite and chalcopyrite. Residual soils overlying deposits may contain anomalous amounts of rutile.

Geochemical Signature: Cu + Mo ± Au + Ag + W + B + Sr center, Pb, Zn, Au, As, Sb, Se, Te, Mn, CO, Ba, and Rb outer. Locally Hi and Sn form most distal anomalies. High S in all zones. Some deposits have weak U anomalies.

EXAMPLES

Bingham, USUT	(Lanier and others, 1978)
San Manuel, USAZ	(Lowell and Guilbert, 1970)
El Salvador, CILE	(Gustafson and Hunt, 1975)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu

By Donald A. Singer, Dan L. Mosier, and Dennis P. Cox

COMMENTS All porphyry copper deposits with available grades and tonnages were included in these data in order to provide a model for cases where it is not possible to use the gold-rich or molybdenum-rich models. Parts of the porphyry copper deposits which could be considered skarn were included in these data. Gold grade is correlated with tonnage (r = -0.49, n = 81) and with molybdenum grade (r = -0.45, n = 55). See figs. 51-53.

DEPOSITS

Name	Country
Afton	CNBC
Ajax	CNBC
Ajo	USAZ
Am	CNBC
Amacan	PLPN
Andacolla	CILE
Ann	CNBC
Ann Mason	USNV
Arie	PPNG
Atlas Carmen	PLPN
Atlas Frank	PLPN
Atlas Lutopan	PLPN
Axe	CNBC
Aya Aya	PLPN
Bagdad	USAZ
Basay	PLPN
Bear	USNV
Bell Copper	CNBC
Berg	CNBC
Bethlehem	CNBC
Big Onion	CNBC
Bingham	USUT
Bisbee	USAZ
Bluebird	USAZ
Bond Creek	USAK
Boneng Lobo	PLPN
Bozshchaku	URRS
Brenda	CNBC
Brenmac	USWA
Butilad	PLPN
Butte	USMT
Campanamah	AGTN
Cananea	MXCO
Canariaco	PERU
Cariboo Bell	CNBC
Carpenter	USAZ
Cash	CNYT
Casino	CNYT
Castle Dome	USAZ
Catface	CNBC
Catheart	USMN
Cerro Blanco	CILE
Cerro Colorado	CILE
Cerro Colorado	PANA
Cerro Verde	PERU
Chaucha	ECDR
Chuquicamata	CILE
Coalstoun	AUQL
Copper Basin	USAZ
Copper Cities	USAZ
Copper Creek	USAZ
Copper Flat	USNM
Copper Mountain	CNBC
Cordon	PLPN
Cuajone	PERU
Cubuagan	PLPN
Dexing	CINA
Dizon	PLPN
Dorothy	CNBC
Dos Pobres	USAZ
Eagle	CNBC
El Abra	CILE
El Arco	MXCO
El Pachon	AGTN
El Salvador	CILE
El Soldado	CILE
El Teniente	CILE
Elatsite	BULG
Ely	USNV
Escondida	CILE
Esperanza	CILE
Exotica	CILE
Fish Lake	CNBC
Florence	USAZ
Frieda River	PPNG
Galaxy	CNBC
Galore Creek	CNBC
Gambier Island	CNBC
Gaspe	CNQU
Gibraltar	CNBC
Glacier Peak	USWA
Granisle	CNBC
Hale-Mayabo	PLPN
Heddleston	USMT
Helvetia	USAZ
Highmont	CNBC
Hinobaan	PLPN
Huckleberry	CNBC
Ingerbelle	CNBC
Inguaran	MXCO
Ino-Capaya	PLPN
Inspiration	USAZ
Iron Mask	CNBC
Island Copper	CNBC
Ithaca Peak	USAZ
June	CNBC
Kadzharan	URAM
Kalamaton	PLPN

Kalamazoo-San Manuel	USAZ
Kalmakyr	URUZ
Kennon	PLPN
King-King	PLPN
Kirwin	USWY
Kounrad	URKZ
Krain	CNBC
Kwanika	CNBC
La Alumbrera	AGTN
La Caridad	MXCO
La Florida	MXCO
La Verde	MXCO
Lakeshore	USAZ
Lights Creek	USCA
Lornex	CNBC
Lorraine	CNBC
Los Bronces	CILE
Los Pelambres	CILE
Los Pilares	MXCO
Lumbay	PLPN
Luna-Bash	PLPN
MacArthur	USNV
Maggie	CNBC
Majdanpek	YUGO
Mamut	MDGS
Mantos Blancos	CILE
Mapula	PLPN
Marcopper	PLPN
Margaret	USWA
Marian	PLPN
Mazama	USWA
Metcalf	USAZ
Michiquillay	PERU
Middle Fork	USWA
Mineral Butte	USAZ
Misty	CNBC
Mocha	CILE
Mocoa	CLBA
Moniwa	BRMA
Morenci	USAZ
Morococha	PERU
Morrison	CNBC
Mountain Mines	PLPN
Mount Canninda	AUQL
Namosi East	FIJI
Namosi West	FIJI
North Fork	USWA
Ok	CNBC
Ok Tedi	PPNG
Orange Hill	USAK
Pampa Norte	CILE
Panguna	PPNG
Paramillos	AGTN
Parks	AUNS
Pashpap	PERU
Petaquilla	PANA
Philippine	PLPN
Pima-Mission	USAZ
Plurhinaler	THLD
Poison Mountain	CNBC
Potrerillos	CILE
Primer	CNBC
Quebrada Blanca	CILE
Quelleveco	PERU
Ray	USAZ
Recsk	HUNG
Red Chris	CNBC
Red Mountain	USAZ
Rio Blanco	CILE
Rio Vivi	PTRC
Sacaton (E-W)	USAZ
Safford (KCC)	USAZ
Saindak East	PKTN
Saindak North	PKTN
Saindak South	PKTN
Samar	PLPN
San Antonio	PLPN
San Fabian	PLPN
San Juan	USAZ
San Xavier	USAZ
Sanchez	USAZ
Santa Rita	USNM
Santo Nino	PLPN
Santo Tomas	MXCO
Santo Tomas	PLPN
Sar Cheshmeh	IRAN
Schaft Creek	CNBC
Sierra Gorda	CILE
Silver Bell	USAZ
Sipalay	PLPN
Star Mt.-Fubilan	PPNG
Star Mt.-Futik	PPNG
Star Mt.-Nong River	PPNG
Star Mt.-Olgal	PPNG
Sugarloaf Hill	CNBC
Tagpura	PLPN
Tanama	PTRC
Tawi-Tawi	PLPN
Taysan	PLPN
Toledo	PLPN
Toquepala	PERU
Trojan	CNBC
Twin Buttes	USAZ
Tyrone	USNM
Valley Copper	CNBC
Vekol	USAZ
Washington	MXCO
Yandera	PPNG
Yeoval	AUNS
Yerington	USNV

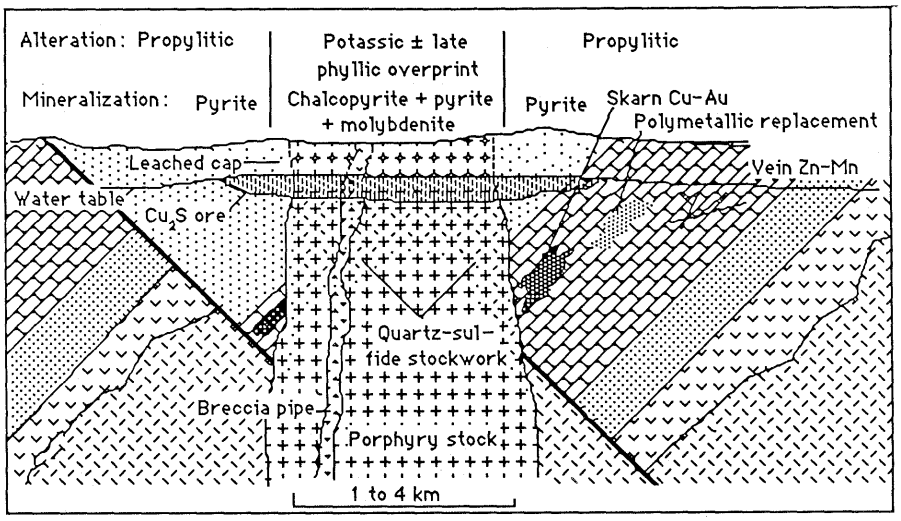

Figure 50. Cartoon cross section illustrating generalized model for porphyry Cu deposits showing relation of ore minerals, alteration zoning, supergene enrichment and associated skarn, replacement, and vein deposits.

Table 3. Types of hydrothermal alteration characteristic of porphyry copper and other deposit models

Type of alteration and synonyms	Original mineral	replaced by	Appearance
Potassic alteration (K-silicate)	plagioclase------- hornblende--------	K-feldspar fine-grained biotite + rutile + pyrite or magnetite. Anhydrite	Rocks look fresh but may have pinkish K-feldspar veinlets and black biotite veinlets and clusters of fine biotite after mafic phenocrysts.
Sodic-calcic alteration (albitic)	K-feldspar-------- biotite----------	oligoclase or albite actinolite + sphene	Rocks are hard and dull white. Biotite is absent. Veinlets of actinolite, epidote, and hematite have hard, white alteration haloes.
Phyllic alteration (quartz-sericite)	plagioclase------- hornblende and biotite----------	sericite sericite + chlorite + rutile + pyrite	Rocks are soft and dull to lustrous white. Pyrite veinlets have distinct, soft translucent gray, sericite haloes. Tourmaline rosettes may be present.
Propylitic alteration	plagioclase------- hornblende and biotite-------	albite or oligoclase + epidote or calcite chlorite + rutile + magnetite or pyrite	Rocks are hard and dull greenish gray. Veinlets of pyrite or chlorite and epidote lack prominent alteration haloes.
Argillic alteration	plagioclase------- mafic minerals----	clay + sericite clay + sericite + chlorite + pyrite	Rocks are soft and white. Tongue will stick to clay-altered minerals.
High alumina (alsic, advanced argillic)	All original and earlier hydrothermal minerals converted to pyrophyllite, alunite, andalusite, corundum, and diaspore with variable amounts of clay and sericite.		Rocks are light colored and moderately soft.

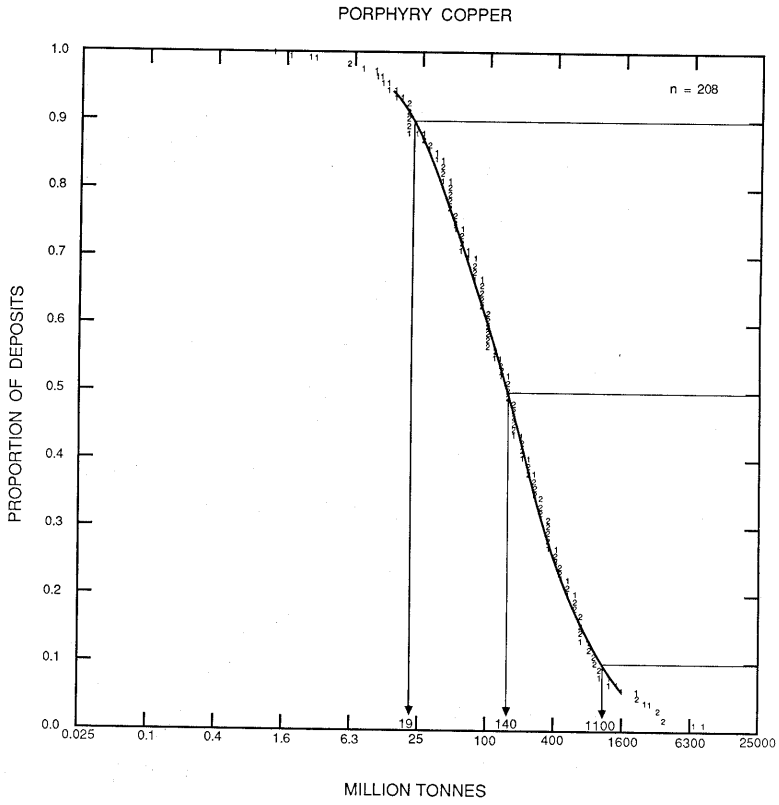

Figure 51. Tonnages of porphyry Cu deposits. Individual digits represent number of deposits.

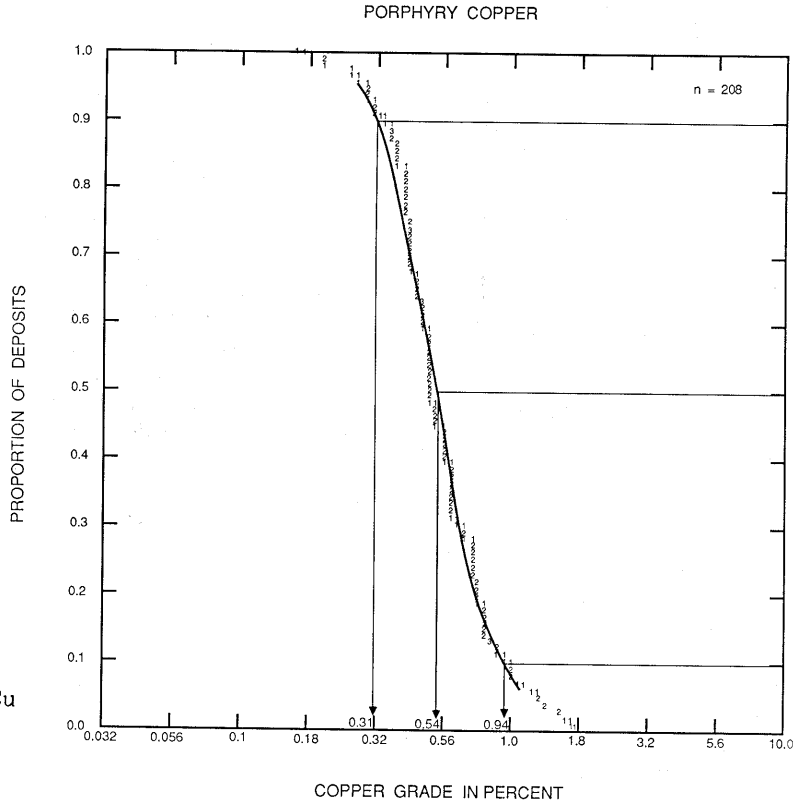

Figure 52. Copper grades of porphyry Cu deposits. Individual digits represent number of deposits.

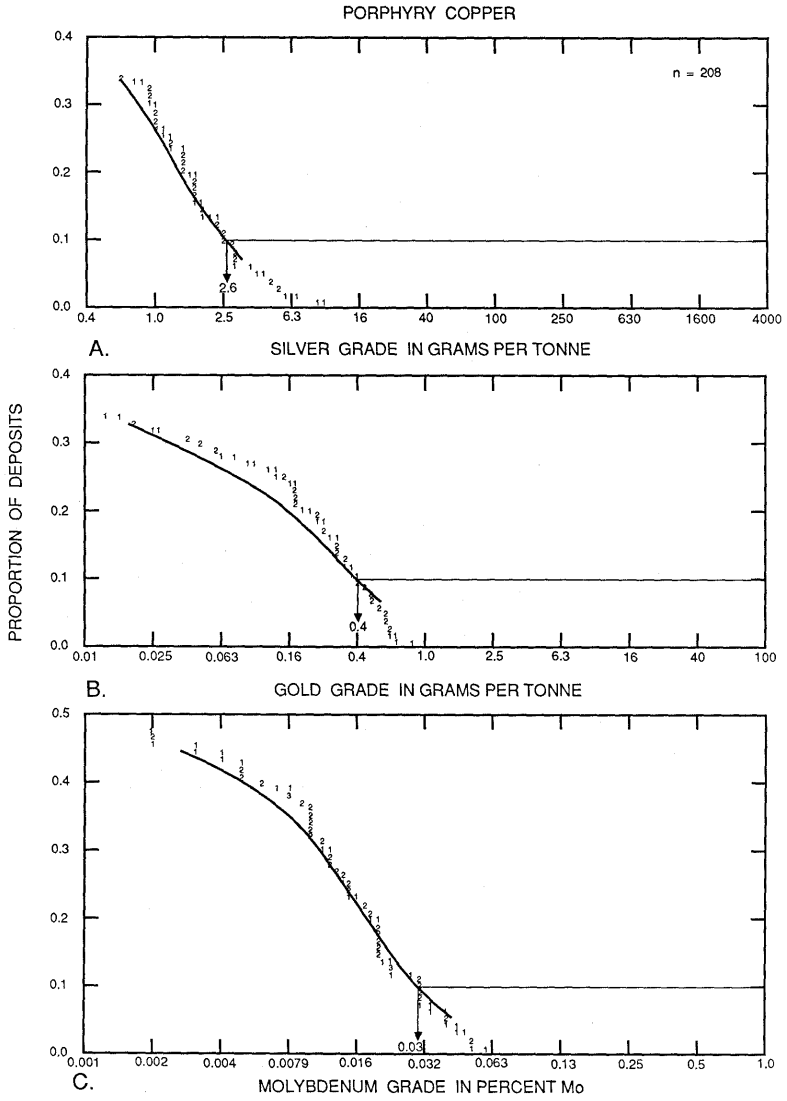

Figure 53. By-product grades of porphyry Cu deposits. A, Silver. B, Gold. C, Molybdenum. Individual digits represent number of deposits.