

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 porphyry 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 pipes, 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 $\pm$ molybdenite; chalcopyrite + magnetite $\pm$ bornite $\pm$ Au; assemblages may be superposed. Quartz + K-feldspar + biotite $\pm$ 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 $\pm$ Au + Ag + W + B + Sr center, Pb, Zn, Au, As, Sb, Se, Te, Mn, CO, Ba, and Rb outer. Locally Hf 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 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

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

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

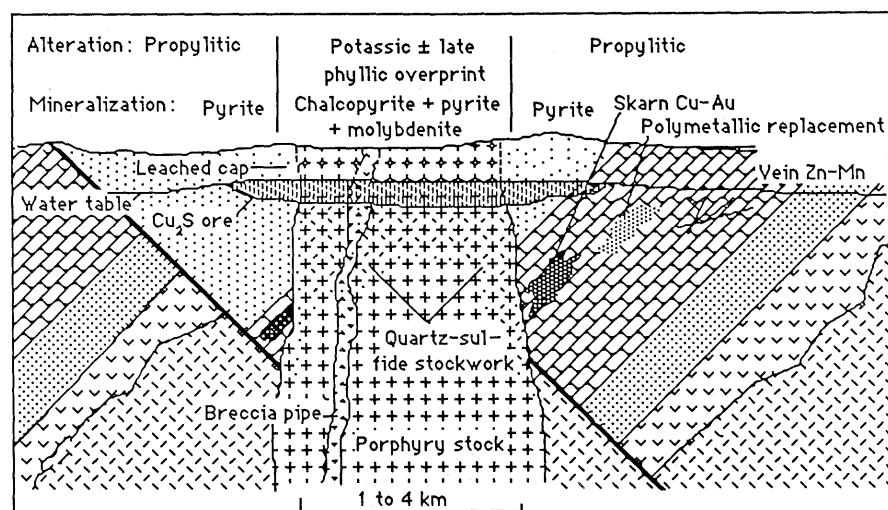


Figure 50. Cartoon cross section illustrating generalized model for porphyry Cu deposits showing relation of ore minerals, alteration zoning, supergene enrichment and associated skarn, replacement, and vein deposits.

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 (albic, advanced argillic)	All original and earlier hydrothermal minerals converted to pyrophyllite, alunite, andalusite, corundum, and diaspora 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.

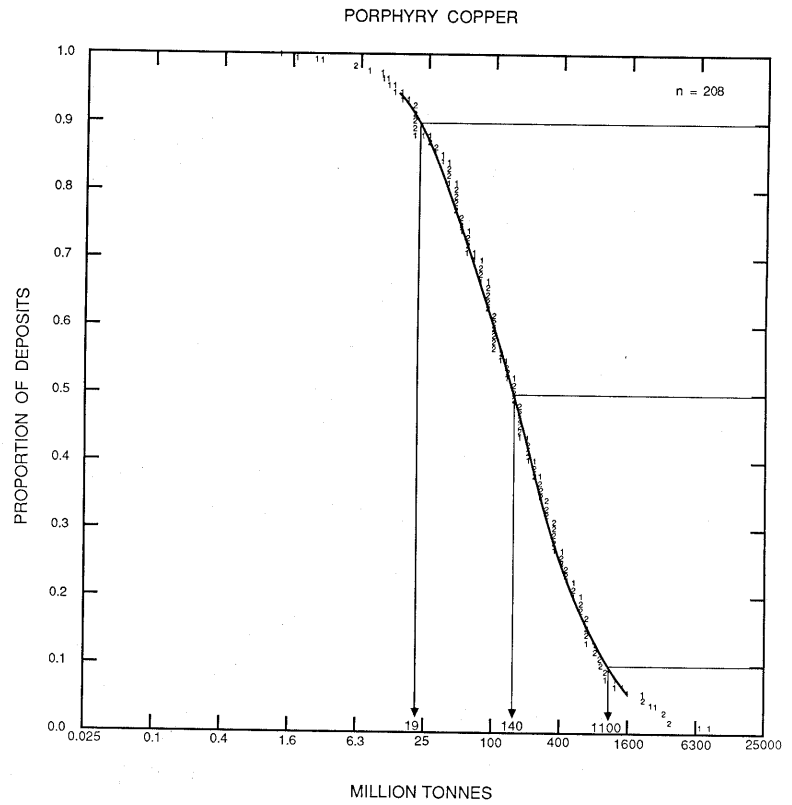
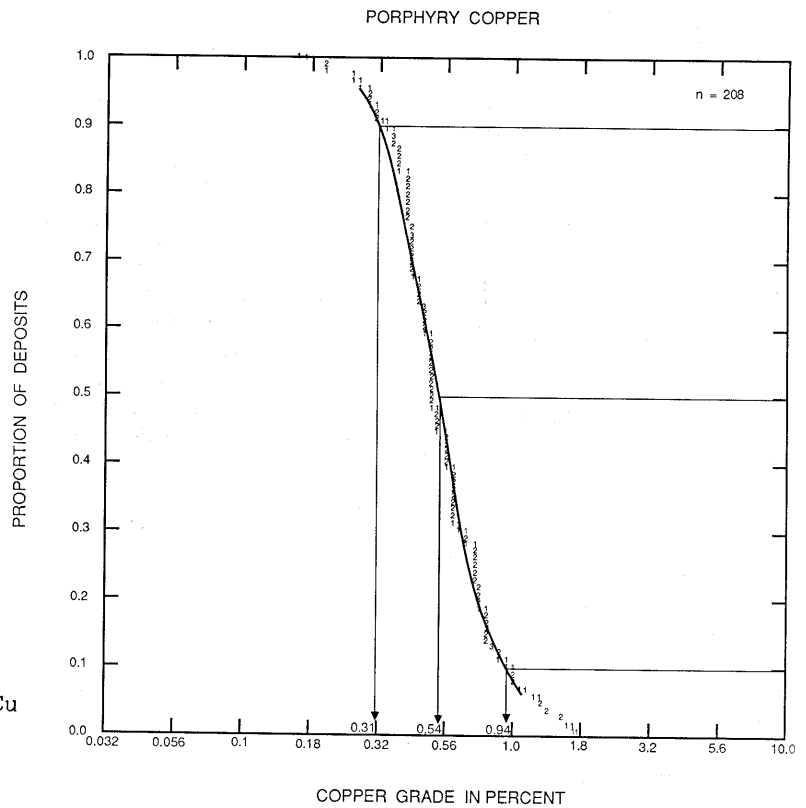


Figure 52. Copper grades of porphyry Cu deposits. Individual digits represent number of deposits.



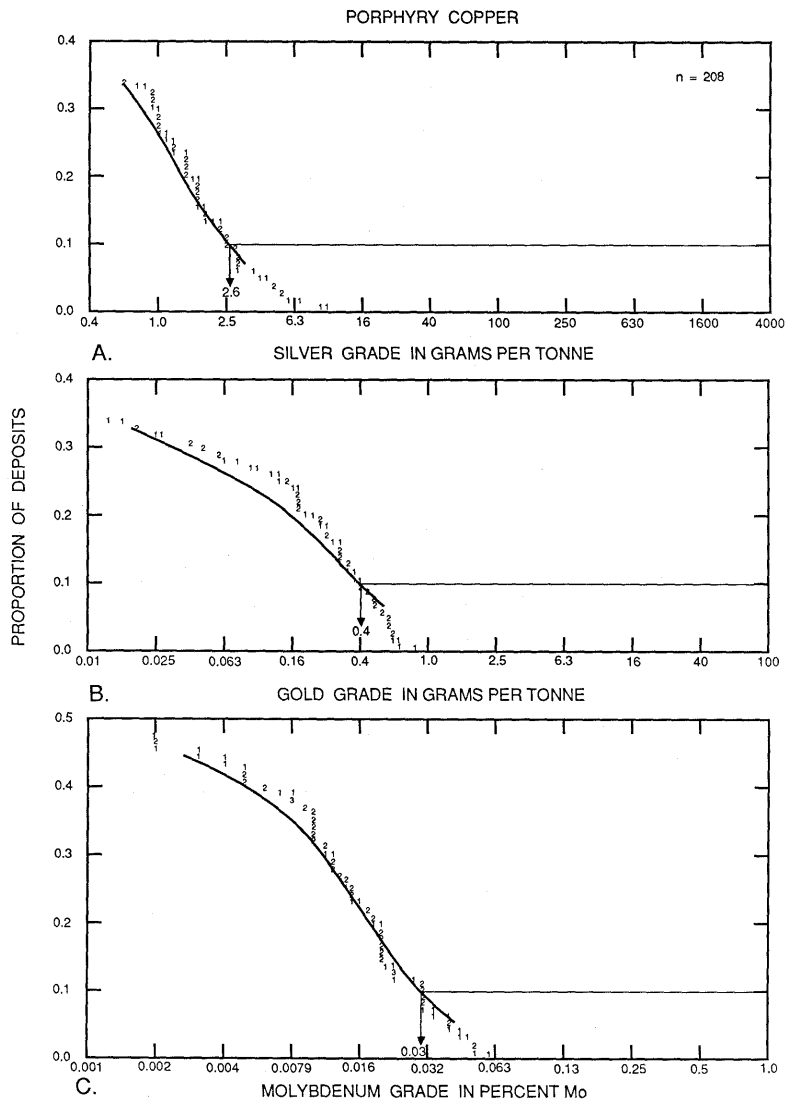


Figure 53. By-product grades of porphyry Cu deposits. **A**, Silver. **B**, Gold. **C**, Molybdenum. Individual digits represent number of deposits.