

## CURSO GL 60 D SEMINARIO PÓRFIDOS CUPRÍFEROS

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Temas a cubrir en el curso y referencias bibliográficas básicas para las respectivas presentaciones y trabajos a desarrollar.

Nota: Esta bibliografía no intenta ser exhaustiva, es responsabilidad de los alumnos revisar y actualizar las referencias bibliográficas de acuerdo al tema de investigación escogido, para su presentación y entrega de un informe escrito a fines del semestre.

### MARCO REGIONAL DE LOS PÓRFIDOS CUPRÍFEROS ANDINOS

- Sillitoe, 1981. Regional aspects of the Andean porphyry copper belt in Chile and Argentina. Trans. Inst. Min. Metall (Section B: Appl. Earth. Sci.), 90, February, 1981. Printed in England.
- Sillitoe, 1977. Permo-carboniferous, Upper Cretaceous, and Miocene porphyry copper-type mineralization in the Argentinian Andes. Economic Geology, V. 72, pp. 99-109.
- Sillitoe, 1992. Gold and Copper Metallogeny in the Central Andes – Past, Present, and Future Exploration Objectives. Economic Geology, V. 87, pp. 2205-2216.
- Sillitoe, 1990. Copper deposits and Andean Evolution. In: Erickson et al. (eds.), 1989, Geology of the Andes and its relation to hydrocarbon and mineral resources. Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series, v. 11.
- Camus, F., 2002. The Andean porphyry systems. In: Cooke, D.R. and Pongrantz, J., eds., Giant Ore Deposits: Characteristics, genesis and exploration. CODES Special Publication 4, Australia, p. 5-21.

### VOLCANISMO CALCO-ALCALINO Y PÓRFIDOS CUPRÍFEROS

- Damon, 1986. Batholith-Volcano Coupling in the Metallogeny of Porphyry Copper Deposits. In: Friedrich et al. (eds) Geology and Metallogeny of Copper Deposits, Springer – Verlag, p. 216-234.
- Gustafson, 1979. Porphyry Copper Deposits and Calc-Alkaline Volcanism. In. McElhinny (ed.) The Earth: Its Origin, Structure and Evolution. Academic Press London Ltd., p. 427-468.
- Sillitoe R.H., 1994, Erosion and collapse of volcanoes: causes of telescoping in intrusion-centered ore deposits. Geology 22:945-948
- Sillitoe RH, Bonham HF (1984) Volcanic landforms and ore deposits. Econ Geol 79:1286-1298
- Sillitoe, R.H., 1973, The tops and bottoms of porphyry copper deposits: Economic Geology, v. 68, p. 799-815.

## **CONDICIONES FISICO-QUÍMICAS FAVORABLES PARA LA FORMACIÓN DE PÓRFIDOS**

- Burnham, 1981. Physicochemical constraints on porphyry mineralization. In: Dickinson and Payne (eds) Relations of tectonics to ore deposits in the Southern Cordillera. Arizona Geological Digest, V. XIX, p. 71-77.
- Burnham, 1979. Magmas and Hydrothermal Fluids. In. Barnes (ed.) Geochemistry of hydrothermal ore deposits, 2nd Edition, John Wiley and Sons, p. 71-136.
- Burnham and Ohmoto, 1980. Late-Stage Processes of Felsic Magmatism. Mining Geology Special Issue, Nº 8, p. 1-11.
- Gustafson, 1978. Some Major Factors of Porphyry Copper Genesis. Economic Geology, V. 73, pp. 600-607.
- Hedenquist, J.W. and Lowerstern, J.B., 1994. The role of magmas in the formation of hydrothermal ore deposits. Nature, V. 370, pp. 519-527.

## **AGUA/VAPOR EN MAGMAS**

- Giggenbach, W.F., 1997. The origin and evolution of fluids in magmatic-hydrothermal systems. In Barnes, H.L. (editor) Geochemistry of hydrothermal ore deposits, 3rd Edition, John Wiley, p. 495-510.
- Giggenbach, W.F., 1992. Magma degassing and mineral deposition in hydrothermal systems along convergent plate boundaries. Economic Geology, V.87, pp. 1927-1944.
- Henley and McNabb, 1977. Magmatic Vapor Plumes and Ground-Water Interaction in Porphyry Copper Emplacement. Economic Geology, V. 73, p. 1-20.
- Whitney, J.A., 1975. Vapor Generation in a Quartz Monzonite magma: A Syntetic Model With Application to Porphyry Copper Deposits. Economic Geology, V. 70, pp. 346-358.
- Whitney, 1988. The origin of granite: The role and source of water in the evolution of granitic magmas. Geological Society of America Bulletin, V. 100, p. 1886-1897.

## **PARTICIÓN DE ELEMENTOS METÁLICOS DESDE MAGMAS A UNA FASE VOLÁTIL**

- Candela and Piccoli, 1995. Model Ore-Metal Partitioning from Melts into Vapor and Vapor/Brine Mixtures. In: Thompson (ed.) Magmas, Fluids, and Ore Deposits. Mineralogical Association of Canada Short Course Series., V. 23, pp. 101-127.
- Candela and Holland, 1984. The partitioning of copper and molybdenum between silicate melts and aqueous fluids. Geochimica and Cosmochimica Acta, V. 48, pp. 373-380.

- Candela and Holland, 1986. A Mass Transfer Model for Copper and Molybdenum in Magmatic Hydrothermal Systems: The origin of Porphyry-Type Ore Deposits. *Economic Geology*, V. 81, pp. 1-19.
- Cline, J.S., 1995. Genesis of Porphyry Copper Deposits: The Behaviour of Water, Chlorine, and Copper in Crystallizing Melts. In. Pierce and Bolm (eds.) *Porphyry Copper Deposits of the American Cordillera*. Arizona Geological Digest 20, p69-82.
- Heinrich et al., 1999. Metal fractionation between magmatic brine and vapor, determined by microanalysis of fluid inclusions. *Geology*, V. 27, p. 755-754.
- Feiss, 1978. Magmatic Sources of Copper in Porphyry Copper Deposits. *Economic Geology*, V. 73, pp.397-404.

## TRANSPORTE DE METALES

- Gammons and Williams-Jones, 1997. Chemical Mobility of Gold in the Porphyry- Epithermal Environment. *Economic Geology*, V. 92, pp. 45-59.
- Heinrich et al., 1999. Metal fractionation between magmatic brine and vapor, determined by microanalysis of fluid inclusions. *Geology*, V. 27, p. 755-754.
- Feiss, 1978. Magmatic Sources of Copper in Porphyry Copper Deposits. *Economic Geology*, V. 73, pp.397-404.
- Roedder, E., 1965, Report on S.E.G. Symposium on the chemistry of ore-forming fluids: *Economic Geology*, v. 60, p. 1380-1403.
- Seward, T.M., 1981, Metal complex formation in aqueous solutions at elevated temperatures and pressures, in Wickman, E, and Rickard, D., eds., *Physics and Chemistry of the Earth*: v. 13-14, p. 113-129.

## ENFRIAMIENTO DE PLUTONES / DURACIÓN DE ACTIVIDAD HIDROTERMAL

- Cathles, 1977. An analysis of the cooling intrusives by ground-water convection which includes boiling. *Economic Geology*, V. 72, pp. 804-826.
- Cathles, 1981. Fluid Flow and Genesis of Hydrothermal Ore Deposits. *Economic Geology*, 75<sup>th</sup> Anniversary Volume, pp. 424-457.
- Jaeger, J.C., 1968. Cooling and Solidification of Igneous Rocks. In. Hess and Poldervaart (eds.). *Basalts, The Poldervaart Treatise on Rocks of Basaltic Composition*. Vol. 2, pp. 503-535.
- Maksaev, V. y Munizaga, F., 2000. Duración de los procesos hidrotermales formadores de yacimientos de tipo pórfido cuprífero gigantes chilenos. IX Congreso Geológico Chileno, Actas, V. 1, Sesión Temática N° 2, pp. 269 - 274. Puerto Varas, Chile.
- Norton, 1978. Sourcelines, Sourceregions, and Pathlines for Fluids in Hydrothermal Systems Related to Cooling Plutons. *Economic Geology*, V.73, pp. 21-28.

Norton, 1982. Fluid and heat transport in pluton environments. In. Titley (ed.) Advances in Geology of the Porphyry Copper Deposits, Southwestern North America, University of Arizona Press, p. 59-72.

Stein, H.J., and Cathles, L.M., 1997. PREFACE: The Timing and Duration of Hydrothermal Events. *Economic Geology*, V. 92, N° 7/8, pp. 763-765.

## GEOCRONOLOGIA DE PORFIDOS

Arribas, A., Jr., Hedenquist, J.W., Itaya, T., Okada, T., Concepción, R.A., and Garcia, J.S., Jr., 1995, Contemporaneous formation of adjacent porphyry and epithermal Cu-Au deposits over 300 ka in northern Luzon, Philippines: *Geology*, v. 23, p. 337-340.

Ballard JR, Palin JM, Williams IS, Chambell IH, Faunes A (2001) Two ages of porphyry intrusion resolved for the super-giant Chuquicamata copper deposit of northern Chile by ELA-ICP-MS and SHRIMP. *Geology* 29:383-386

Clark AH, Archibald DA, Lee AW, Farrar E, Hodgson CJ (1998) Laser probe  $^{40}\text{Ar}/^{39}\text{Ar}$  ages of early- and late-stage alteration assemblages, Rosario porphyry copper-molybdenum deposit, Collahuasi district, I Region, Chile. *Economic Geology*, v. 93, p. 326-337

Cuadra, P., 1986. Geocronología K-Ar del yacimiento El Teniente y áreas adyacentes. *Revista Geológica de Chile*, N° 27, pp. 3-26.

Deckart, K., Clark, A.H., Aguilar, C., Vargas, R., Bertens, A., Mortensen, J.K., and Fanning, M., 2005. Magmatic and Hydrothermal Chronology of the Giant Rio Blanco Porphyry Copper Deposit, Central Chile: Implications for an Integrated U-Pb and  $^{40}\text{Ar}/^{39}\text{Ar}$  Database. *Economic Geology*, v. 100, p. 905-934.

Maksaev V, Zentilli M, Reynolds PH (1988) Geocronología  $^{40}\text{Ar}/^{39}\text{Ar}$  de depósitos de tipo pórfido cuprífero del Norte Grande de Chile. In: Abstr Vol 5th Congreso Geológico Chileno, Santiago, 8-12 August 1988. Vol 1, pp 109-133

Maksaev, V., Munizaga, F., McWilliams M, Fanning, M., Mathur, R., Ruiz, J., and Zentilli, M., 2004 - New chronology for El Teniente, Chilean Andes, from U/Pb,  $^{40}\text{Ar}/^{39}\text{Ar}$ , Re-Os and fission track dating: Implications for the evolution of a supergiant porphyry Cu-Mo deposit (in Sillitoe, R.H., Perelló, J., and Vidal, C.E., eds.) Andean Metallogeny: New Discoveries, Concepts and Updates. Society of Economic Geologists, SEG Special Publication 11, 2004, pp. 15-54

Maksaev, V., Munizaga, F., McWilliams, M., Thiele, K., Arévalo, A., Zúñiga, P., and Floody, R. (2001).  $^{40}\text{Ar}/^{39}\text{Ar}$  Geochronology of the El Teniente Porphyry Copper Deposit. III South American Symposium on Isotope Geology, Extended Abstract Volume (CD), Sociedad Geológica de Chile, Santiago, Chile, pp. 496-499.

Marsh TM, Einaudi MT, McWilliams M (1997)  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology of Cu-Au and Au-Ag mineralization in the Potrerillos district, Chile. *Economic Geology*, V. 92, pp. 784-806.

Masterman, G.J., Cooke, D.R., Berry, R.F., Clark, A.H., Archibald, D.A., Mathur, R., Walshe, J.L., and Durán, M., 2004.  $^{40}\text{Ar}/^{39}\text{Ar}$  and Re-Os Geochronology of Porphyry Copper-

- Molybdenum Deposits and Related Copper-Silver Veins in the Collahuasi District, Northern Chile. Economic Geology, Vol. 99, pp. 673–690.
- Parry, W.T., Wilson, P.N., Moser, D., and Heizler, M., U-Pb Dating of Zircon and 40Ar/39Ar Dating of Biotite at Bingham, Utah, 2001. U-Pb Dating of Zircon and 40Ar/39Ar Dating of Biotite at Bingham, Utah. Economic Geology, Vol. 96, 2001, pp. 1671–1683.
- Pollard, P.J., Taylor, R.G., and Peters, L., 2005. Ages of Intrusion, Alteration, and Mineralization at the Grasberg Cu-Au Deposit, Papua, Indonesia. Economic Geology, v. 100, pp. 1005–1020.
- Richards JP, Noble SR, Pringle MS (1999) A revised Late Eocene age for porphyry Cu magmatism in the Escondida area, northern Chile. Economic Geology, V. 94, pp. 1231-1248
- Zentilli M, Krogh TE, Maksaev V, Alpers CN (1994) Uranium-lead dating of zircons from the Chuquicamata and La Escondida porphyry copper deposits, Chile: inherited zircon cores of Paleozoic age with Tertiary overgrowths. Comunicaciones 45:101-110

## **MODELO TEÓRICO: ¿ES POSIBLE GENERAR MINERALIZACIÓN ECONÓMICA DE TIPO PÓRFIDO CUPRÍFERO A APARTIR DE UN MAGMA CALCOALCALINO TÍPICO?**

Cline. J.S. and Bodnar, R.J., 1991. Can Economic Porphyry Copper Mineralization be generated by a typical calk-alkaline melt? Journal of Geophysical Research, V. 96, p. 8113-8126.

## **PATRONES DE ALTERACIÓN EN PÓRFIDOS CUPRÍFEROS**

Creasey, S.C., 1966, Hydrothermal alteration, in Titley, S.R., and Hicks, C.L., eds., Geology of the porphyry copper deposits-southwestern North America: Tucson, University of Arizona Press, p. 51-74.

Dilles and Einaudi, 1992. Wall-Rock Alteration and Hydrothermal Flow Paths about the Ann-Mason Porphyry Copper Deposit, Nevada --A 6 Km Vertical Reconstruction. Economic Geology, V. 87, pp. 1693-2001

Gustafson, L.B. and Hunt, J.P., 1975. The porphyry copper deposit at El Salvador, Chile. Economic Geology, V. 70, p. 857-912.

James, 1971. Hypothetical Diagrams of Several Porphyry Copper Deposits. Economic Geology, V. 66, pp. 43-47.

Lowell and Gilbert, 1970. Lateral and vertical Alteration-Mineralization Zoning in Porphyry Ore Deposits. Economic Geology, V. 65, pp. 373-408.

Nielson, R.L., 1976, Recent developments in the study of porphyry copper geology-a review: Canadian Institute of Mining and Metallurgy, Special Volume 15, p. 487-500.

Parry, W.T., Jasumback, M., and Wilson, P.N., Clay Mineralogy of Phyllitic and Intermediate Argillic Alteration at Bingham, Utah. *Economic Geology*, Vol. 97, 2002, pp. 221–239.

Rose, 1970. Zonal Relations of Wallrock Alteration and Sulfide Distribution at Porphyry Copper Deposits. *Economic Geology*, V. 65, pp. 920-936.

### **ALTERACIÓN ARGÍLICA AVANZADA SUPRA-PORFIDOS; LITHOCAPS de Richard Sillitoe**

Corbett, G.J., and Leach, T.M., 1998. Southwest Pacific Rim Gold-Copper Systems: Structure, Alteration, and Mineralization. Special Publication Number 6, Society of Economic Geologists, 236 p. Capítulo 6 High Sulfidation Gold-Copper Systems; High Sulfidation Systems formed as shoulders to porphyry intrusions, p. 105-106.

Sillitoe, 1995. Exploration of porphyry copper lithocaps. *PANCRIM'95*, pp. 527-532.

Sillitoe et al., 1998. Advanced argillic lithocaps in the Bolivian tin-silver belt. *Mineralium Deposita*, V. 33, p. 539-546.

### **TRANSICIÓN PÓRFIDO A EPITERMAL**

Muntean, J.L., and Einaudi, M.T., 2001. Porphyry-Epithermal Transition: Maricunga Belt, Northern Chile. *Economic Geology*, Vol. 96, 2001, pp. 743–772.

### **CUBIERTAS LIXIVIADAS**

Anderson, 1982. Characteristics of leached capping and techniques of appraisal. In. Titley (ed.) *Advances in Geology of Porphyry Copper Deposits, Southwestern North America*, University of Arizona Press, p. 275-295.

Gilmour, P., 1995. A Field Guide to Leached Capping Interpretation. In. Pierce and Bolm (eds.) *Porphyry Copper Deposits of the American Cordillera*, Arizona Geological Society Digest 20, p.169-179.

### **FORMACIÓN DE STOCKWORK Y BRECHAS EN PÓRFIDOS**

Burnham, 1985. Energy Release in Subvolcanic Environments: Implications for Breccia Formation. *Economic Geology*. V. 80, pp. 1515-1522.

Phillips, W.J., 1973. Mechanical effects of retrograde boiling and its probable importance in the formation of some porphyry ore deposits. *Transactions Inst. Mining and Metallurgy* (section B: Appl. Earth. Sci.), Printed in England, p. B90-98.

## ZONACIÓN GEOQUÍMICA EN PÓRFIDOS CUPRÍFEROS

- Chaffee, M.A., 1982. A Geochemical Study of the Kalamazoo Porphyry Copper Deposit: Pinal County, Arizona. In: Titley, S.R. (ed.) Advances in Geology of the Porphyry Copper Deposits, Southwestern North America. The University of Arizona Press, p.211-226.
- Jones, B.K., 1992. Application of metal zoning to gold exploration in porphyry copper deposits. Journal of Geochemical Exploration, V. 43, p. 127-155.

## DIATREMAS Y PÓRFIDOS CUPRÍFEROS

- Laznicka, Peter, 1988. Breccia and Coarse Fragmentites: petrology, environments, association, ores. Elsevier, 831 p.
- Sillitoe (1985). Ore Related Breccias in Volcanoplutonic Arcs, Economic Geology, V. 80, Nº 6, pp. 1467-1514.

## EXPLORACIÓN GEOFÍSICA DE PÓRFIDOS

- Silva, L., 1973. Criterios usados en la selección de los métodos geofísicos de prospección. Revista Geológica Chilena, Nº 1, p. 37-63.
- Van Blaricom, 1986?.(compiler) Practical Geophysics for the Exploration Geologist. Northwest Mining Association, 633 Peyton Bldng., Spokane, WA 99201., 303 p.

## EXPLORACIÓN GEOQUÍMICA DE PÓRFIDOS

- Chaffee, M.A., 1983. Geochemical Prospecting Techniques for Porphyry Copper Deposits: Southwestern United States and Northern Mexico. In: Titley (editor) Advances in Geology of the Porphyry Copper Deposits, Southwestern North America, The University Arizona Press, p. 297-310.

## PÓRFIDOS RICOS EN ORO

- Cornejo, C., 2000. Pórfidos de Oro de la Franja de Maricunga, III Región, Chile: Una Revisión Actualizada. Memoria de Título, Departamento de Geología, Universidad de Chile, 160 p.
- Harris, A.C., Holding, S.D. and White, N.C., 2005. Bajo de la Alumbrera Copper-Gold Deposit: Stable Isotope Evidence for a Porphyry-Related Hidrotermal System Dominated by Magmatic Aqueous Fluids. Economic Geology, v. 100, p. 863-886.

Perelló, J., Urzúa, F., Cabello, J., and Ortiz, F., 1994. Clustered gold-bearing Oligocene porphyry copper and associated epithermal mineralization at La Fortuna, Vallenar Region, Northern Chile. 7º Congreso Geológico Chileno, Actas, V. II, pp. 1607-1612.

Sillitoe, 1997. Characteristics and controls of the largest porphyry copper-gold and epithermal gold deposits in the circum-Pacific region. Australian Journal of Earth Sciences, V. 44, pp. 373-388.

## PÓRFIDOS ALCALINOS/ALTERACIÓN SÓDICO-CÁLCICA

Arancibia, O. and Clark, A., 1996. Magnetite-Amphibole-Plagioclase Alteration-Mineralization in the Island Copper Porphyry Copper-Gold-Molybdenum Deposit, British Columbia. Economic Geology, V. 91, pp. 402-438.

Carten, R., 1986. Sodium-Calcium Metasomatism: Chemical, Temporal, and Spatial Relationships at the Yerinton, Nevada, Porphyry Copper Deposits. Economic Geology, V. 81, pp. 1495-1519.

Lang et al., 1995. Porphyry Copper-Gold Deposits Related to Alkalic Igneous Rocks in the Triassic-Jurassic Arc Terranes of British Columbia. In. Pierce and Bolm (eds.) Porphyry Copper Deposits of the American Cordillera, Arizona Geological Society Digest 20, p. 219-236.

## PROCESOS SUPERGENOS, ENRIQUECIMIENTO SECUNDARIO EN PÓRFIDOS CUPRÍFEROS

Ague, J.J. and Brimhall, G.H., 1989. Geochemical modelling of steady state fluid flow and chemical reaction during supergene enrichment of porphyry copper deposits. Economic Geology, V. 84, pp. 506-528.

Alpers, C.N. and brimhall, G.H., 1988. Middle Miocene climatic change in the Atacama Desert, northern Chile: evidence from supergene mineralization at La Escondida. Geological Society of America Bulletin, V. 100, pp. 1640-1656.

Alpers, C.N. and Brimhall, G.H., 1989. Paleohydrologic evolution and geochemical dynamics of cumulative supergene metal enrichment at La Escondida, Atacama Desert, Northern Chile. Economic Geology, V. 84, pp. 229-255.

Bouzari, F., and Clark, A.H., 2002. Anatomy, Evolution, and Metallogenic Significance of the Supergene Orebody of the Cerro Colorado Porphyry Copper Deposit, I Región, Northern Chile. Economic Geology, V. 97, p. 1701-1740.

Chavez Jr., W.X., 2000. Supergene Oxidation of Copper Deposits: Zoning and Distribution of Copper Oxide Minerals. SEG Newsletter Number 41, Lead Article, April 2000 Issue.

Flores, R., 1985. Control del enriquecimiento supérgeno en el yacimiento Chuquicamata, Chile. Actas IV Congreso Geológico Chileno, V. 2, pp. 3-228 - 3-249, Antofagasta.

- Quang, C.X., Clark, A.H., Lee, J.K.W., and Hawkes, N., 2005. Response of Supergene Processes to Episodic Cenozoic Uplift, Pediment Erosion, and Ignimbrite Eruption in the Porphyry Copper Province of Southern Perú, *Economic Geology*, v. 100, pp. 87–114.
- Quang, C.X., Clark, A.H., Lee, J.W., and Guillén, J., 2003.  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  Ages of Hypogene and Supergene Mineralization in the Cerro Verde-Santa Rosa Porphyry Cu-Mo cluster, Arequipa, Peru. *Economic Geology*, Vol. 98, 2003, pp. 1683–1696.
- Sillitoe, R.H., and McKee, E.H., 1996. Age of Supergene Oxidation and Enrichment in the Chilean Porphyry Copper Province. *Economic Geology*, V. 91, pp. 164-179.
- Titley and Marozas, 1995. Processes and Products of Supergene Copper Enrichment. In. Pierce and Bolm (eds.) *Porphyry Copper Deposits of the American Cordillera*, Arizona Geological Society Digest 20, p. 156-168.

## DEPÓSITOS EXÓTICOS DERIVADOS DE PÓRFIDOS CUPRÍFEROS

Mote, T.I., Brimhall, G.H., Tidy, E., Muller, G., and Carrasco, P., 2001. Application of Mass-Balance Modeling of Sources, Pathways, and Sinks of Supergene Enrichment to Exploration and Discovery of the Quebrada Turquesa Exotic Copper Orebody, El Salvador District, Chile. *Economic Geology*, V. 96, pp. 367-386.

Münchmeyer, C., 1996. Exotic Deposits - Products of Lateral Migration of Supergene Solutions from Porphyry Copper Deposits. Society of Economic Geologists, Special Publication N° 5, p. 43-58.

## ISÓTOPOS EN PÓRFIDOS CUPRÍFEROS

Titley, S.R., 2001, Crustal affinities of metallogenesis in the American southwest: *Economic Geology*, v. 96, p. 1323-1342.

Bouse, R.M., Ruiz, J., Titley, S.R., Tosdal, R.M., and Wooden, J.L., 1999, Lead isotope compositions of Late Cretaceous and Early Tertiary igneous rocks and sulfide minerals in Arizona: Implications for the sources of plutons and metals in porphyry copper deposits: *Economic Geology*, v. 94, p. 211-244.

Lang, J.R., and Titley, S.R., 1998, Isotopic and Geochemical characteristics of Laramide magmatic systems in Arizona and implications for the genesis of porphyry copper deposits: *Economic Geology*, v. 93, p. 138-170.

Anthony EY, Titley SR (1988) Progressive mixing of isotopic reservoirs during magma genesis at the Sierrita porphyry copper deposit, Arizona: inverse solutions. *Geochimica et Cosmochimica Acta* 52:2235-2249

Field, C.W. and Gustafson, L.B., 1976. Sulfur isotopes in the porphyry copper deposit at El Salvador, Chile. *Economic Geology*, V. 71, pp. 1533-1548.

- Halpern, M., 1979. Strontium isotope composition of rocks from the Disputada copper mine, Chile. *Economic Geology*, V. 74, pp. 129-130.
- Kusakabe, M.; Nakagawa, S.; Hori, M.; Matsuhita, Y.; Ojeda, J. and Serrano, L., 1984. Oxygen and sulfur isotopic compositions of quartz, anhydrite, and sulfide minerals from El Teniente and Río Blanco porphyry copper deposits, Chile. *Bulletin of Geological Survey of Japan*, Vol. 35 (11), pp. 583 – 614.
- Kusakabe, M.; Hori, M and Matsuhita, Y., 1990. Primary mineralization – alteration of the El Teniente and Río Blanco porphyry copper deposits, Chile. Stable isotopes, fluid inclusions, and Mg 2+/Fe2+/Fe3+ ratios of hydrothermal biotite. *Geology Department & Extension, The University of Western Australia, Publication N° 23*, 382 p.
- Maksaev, 1990. Metallogeny, Geological Evolution, and Thermochronology of the Chilean Andes Between Latitudes 21° and 26° South, and the Origin of Major Porphyry Copper Deposits. Ph.D. Thesis, Dalhousie University, Canada, 554 p.
- Mathur R, Ruiz J, Munizaga F (2000) Relationship between copper tonnage of Chilean base-metal porphyry deposits and Os isotope ratios. *Geology* 28:555-558
- Puig, A., 1988. Geologic and metallogenic significance of the isotopic composition of lead in galenas of the Chilean Andes. *Economic Geology*, V. 83, pp. 843-858.
- Sasaki, A., Ulriksen, C., Sato, K. and Ishihara, S., 1984. Sulphur isotope reconnaissance of porphyry copper and manto-type deposits in Chile and the Philippines: *Bulletin of the Geological Survey of Japan*, V. 35, pp. 615-622.
- Sheppard and Gustafson, 1976. Oxygen and hydrogen isotopes in the porphyry copper deposit at El Salvador, Chile. *Economic Geology*, v. 71, pp. 1549-1559.
- Sillitoe, R.H. and Hart, S.R., 1984. Lead isotopic signatures of porphyry copper deposits in oceanic and continental settings, Colombian Andes. *Geochimica et Cosmochimica Acta*, V. 48, pp. 2135-2142.
- Skewes, A. and Stern, Ch.R., 1996. Late Miocene Mineralized Breccias in the Andes of Central Chile: Sr- and Nd-isotopic evidence for multiple magmatic sources. Special Publication Number 6, Society of Economic Geologists, p. 33-42.

## PETROLOGÍA DE PÓRFIDOS

- Campos, E., Touret, J.L.R., Nikogosian I., and Delgado, J., (2002) Overheated, Cu-bearing magmas in the Zaldívar porphyry-Cu deposit, Northern Chile. *Geodynamic consequences. Tectonophysics* 345 (2002) 229– 251.
- Dilles JH (1987) Petrology of the Yerington Batholith, Nevada: evidence for evolution of porphyry copper ore fluids. *Economic Geology* 82:1750-1789
- Hollings, P., Cooke, D., and Clark, A.H., 2005. Regional Geochemistry of Tertiary Igneous Rocks in Central Chile: Implications for the Geodynamic Environment of Giant Porphyry Copper and Epithermal Gold Mineralization. *Economic Geology*, v. 100, p. 887-886.

- Lopez-Escobar, L., 1982. Características geoquímicas de rocas ígneas asociadas con pórfidos cupríferos chilenos. Revista Geológica de Chile, No.17, pp. 3-19.
- Maksaev, 1990. Metallogeny, Geological Evolution, and Thermochronology of the Chilean Andes Between Latitudes 21° and 26° South, and the Origin of Major Porphyry Copper Deposits. Ph.D. Thesis, Dalhousie University, Canada, 554 p.
- Oyarzun R, Márquez A, Lillo J, López I, Rivera S (2001) Giant versus small porphyry copper deposits of Cenozoic age in northern Chile: adakitic versus normal calc-alkaline magmatism. Mineralium Deposita 36:794-798
- Rabbia, O.M., Hernández, L.B. (2000) Quartz diorite trend in porphyry copper deposits: underlying petrological processes and implications in copper metallogenesis. Mineral Metal 6:416-423
- Rabbia, O.M., Hernández, L.B., King, R.W. and López-Escobar, L., (2001) Discussion on "Giant versus small porphyry copper deposits of Cenozoic age in northern Chile: adakitic versus normal calc-alkaline magmatism" by Oyarzun et al., Mineralium Deposita 36:794-798.
- Richards, J.P. (2001). Discussion on "Giant versus small porphyry copper deposits of Cenozoic age in northern Chile: adakitic versus normal calc-alkaline magmatism". Mineralium Deposita 36: 794-798.

## TECTÓNICA Y PÓRFIDOS CUPRÍFEROS

- Cooke, D.R., Hollings, P. and Walshe, J.L., 2005. Giant Porphyry Deposits: Characteristics, Distribution, and Tectonic Controls. Economic Geology, v. 100, p. 801-818.
- Gow, P.A. and Walshe, J.L., 2005. The Role of Preexisting Geologic Architecture in the Formation of Giant Porphyry-Related Cu ± Au Deposits: Examples from New Guinea and Chile. Economic Geology, v. 100, p. 819-834.
- Richards, J.P., 2001. Tectono-Magmatic Precursors for Porphyry Cu-(Mo-Au) Deposit Formation. Economic Geology, Vol. 98, pp. 1515–1533

## TRABAJOS GENERALES DE PÓRFIDOS

- Ambrus, J., 1979. Emplazamiento y Mineralización de los Pórfidos Cupríferos de Chile. Tesis de Doctorado, Depto. de Cristalográfica y Mineralogía, Facultad de Ciencias, Univ. De Salamanca, España, 314 p.
- Ambrus, J., 1980. Evolución del Concepto de Pórfido Cuprífero. Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos, Instituto de Ingenieros de Minas de Chile, v.3, p. 9-51.
- Boric, R., Díaz, F. y Maksaev, V., 1990. Geología y yacimientos metalíferos de la Región de Antofagasta. Servicio Nacional de Geología y Minería, Boletín 40, Santiago, 246 p.

- Clark, A.H. (1993). Are outsize porphyry copper deposits either anatomically or environmentally distinctive? In: Whiting, B.H., Mason, R., Hodgson, C.J. (eds) Giant ore deposits. Society of Economic Geologists, Special Publication N° 2, p. 213-283.
- Cooke, D.R., Hollings, P. and Walshe, J.L., 2005. Giant Porphyry Deposits: Characteristics, Distribution, and Tectonic Controls. *Economic Geology*, v. 100, p. 801-818.
- Hedenquist, J.W. and Richards, J.P., 1998. The Influence of Geochemical Techniques on the Development of Genetic Models for Porphyry Copper Deposits. In: Richards, J.P. and Larson, P.B. (eds.) Techniques in Hydrothermal Ore Deposits Geology. Society of Economic Geologists, *Reviews in Economic Geology*, V. 10, p. 235-256.
- Hunt, J.P., 1980. Porphyry Copper Deposits. *Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos*, Instituto de Ingenieros de Minas de Chile, v.1, p. 9-40.
- Schroeter, T.G., ed., 1995, Porphyry deposits of the northwestern Cordillera of North America: Canadian Institute of Mining Metallurgy and Petroleum, Special Volume 46, 888 p.
- Titley, S.R., ed., 1982, Advances in geology of the porphyry copper deposits, southwestern North America: Tucson, University of Arizona Press, 560 p.
- Tosdal, R.M. and Richards, J.P., 2001. Magmatic and Structural Controls on the Development of Porphyry Cu ± Mo ± Au Deposits. In: Richards, J.P. and Tosdal, R.M. (eds.) Structural Controls on Ore Genesis. Society of Economic Geologists, *Reviews in Economic Geology*, V. 14, p.157-181.

## OTROS

- Alfaro, G., 1980. Prospección de pórfidos cupríferos en la zona central-sur de Chile. *Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos*, Instituto de Ingenieros de Minas de Chile, v.2, p.295-313.
- Bouzari, F., and Clark, A.H., 2002. Anatomy, Evolution, and Metallogenic Significance of the Supergene Orebody of the Cerro Colorado Porphyry Copper Deposit, I Región, Northern Chile. *Economic Geology*, V. 97, p. 1701-1740.
- Camus, F., 2001. Geología del Yacimiento Gabi Sur. Proexplo 2001, II Congreso Internacional de Prospectores y Exploradores, 24-27 Abril 2001, Lima, Perú, p. 1-6.
- Harris, A.C., Golding, S.D., and White, N.C., 2005. Bajo de la Alumbra Copper-Gold Deposit: Stable Isotope Evidence for a Porphyry-Related Hydrothermal System Dominated by Magmatic Aqueous Fluids. *Economic Geology*, v. 100, pp. 863-886.
- Landwing, M.R., Dillenbeck, E.D., Leake, M.H., and Heinrich, C.A., 2002. Evolution of the Breccia-Hosted Porphyry Cu-Mo-Au Deposit at Agua Rica, Argentina: Progressive Unroofing of a Magmatic Hydrothermal System. *Economic Geology*, Vol. 97, 2002, pp. 1273-1292
- Lickfold, V., Cooke, D.R., Smith, S.G., and D. Ullrich, T.D., 2003. Endeavour Copper-Gold Porphyry Deposits, Northparkes, New South Wales: Intrusive History and Fluid Evolution. *Economic Geology*, Vol. 98, 2003, pp. 1607-1636.

- Perelló, J., Carlotto, V., Zárate, A., Ramos, P., Posso, H., Neyra, C., Caballero, A., Fuster, N., and Muhr, R., 2003. Porphyry-Style Alteration and Mineralization of the Middle Eocene to Early Oligocene Andahuaylas-Yauri Belt, Cuzco Region, Peru Economic Geology, Vol. 98, 2003, pp. 1575–1605.
- Proffett, J.P., 2003. Geology of the Bajo de la Alumbrera Porphyry Copper-Gold Deposit, Argentina. Economic Geology, Vol. 98, 2003, pp. 1535–1574
- Ross, P-S., Jébrak, M., and Walker, B.M., Discharge of Hydrothermal Fluids from a Magma Chamber and Concomitant Formation of a Stratified Breccia Zone at the Questa Porphyry Molybdenum Deposit, New Mexico. Economic Geology, Vol. 97, 2002, pp. 1679–1699.
- Singer, D.A., Berger, V.I., Menzie, W.D., and Berger, B.R., 2005. Porphyry Copper Deposit Density. Economic Geology, v. 100, pp. 491–514.
- Tapia, J., Crespo, H., y Collao, S., 1998. Antucoya, Pórfido Cuprífero en la Cordillera de la Costa II Región, Chile. Actas X Congreso Latinoamericano de Geología y VI Congreso Nacional de Geología Económica, vol. III, p. 250-255.
- Ulrich, T., and Heinrich, C.A., 2001. Geology and Alteration Geochemistry of the Porphyry Cu-Au Deposit at Bajo de la Alumbrera, Argentina. Economic Geology, Vol. 96, 2001, pp. 1719–1742.
- Ulrich, T., Günter, D., and Heinrich, C.A., 2001. The Evolution of a Porphyry Cu-Au Deposit, Based on LA-ICP-MS Analysis of Fluid Inclusions: Bajo de la Alumbrera, Argentina. Economic Geology, Vol. 96, 2001, pp. 1743–1774.
- Wilson, A.J., Cooke, D.R., and Harper, B.L., 2003. The Ridgeway Gold-Copper Deposit: A High-Grade Alkaline Porphyry Deposit in the Lachlan Fold Belt, New South Wales, Australia. Economic Geology, Vol. 98, 2003, pp. 1637–1666.

## PÓRFIDOS CUPRÍFEROS CHILENOS

Nota: Este listado corresponde principalmente a trabajos publicados sobre pórfidos cupríferos chilenos. Su intención es proporcionar una bibliografía de los principales yacimientos de este tipo existentes en el país. La lista no intenta ser exhaustiva y no incluye un gran número de memorias de título que tratan distintos aspectos de estos grandes depósitos minerales.

### El Teniente

- Camus, F., 1975. Geology of El Teniente orebody with emphasis on wall rock alteration. Economic Geology, Vol. 70, N° 8, pp. 1342–1372.
- Cannel, J., Cooke, D.R., Walshe, J.L., and Stein, H., 2005. Geology, Mineralization, Alteration, and Structural Evolution of the El Teniente Porphyry Cu-Mo Deposit. Economic Geology, v. 100, pp. 979–1003.
- Cuadra, P., 1986. Geocronología K-Ar del yacimiento El Teniente y áreas adyacentes. Revista Geológica de Chile, N° 27, pp. 3–26.

- Hernandez, E., Letelier, C., Letelier, O., Mestre, A., Portigliati, C., 1980. Geología, distribución y cálculo de reservas de molibdeno en El Teniente. Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos, Instituto de Ingenieros de Minas de Chile, v.2, p. 364-383.
- Howell, F.H. and Molloy, J.S., 1960. Geology of the Braden orebody, Chile, South America. Economic Geology, Vol. 55, Nº 5, pp. 863-905
- Lindgren, W. and Bastin, E.S., 1922. Geology of the Braden mine, Rancagua, Chile. Economic Geology, Vol. 17, pp. 75–79.
- Maksaev, V., Munizaga, F., McWilliams M, Fanning, M., Mathur, R., Ruiz, J., and Zentilli, M., 2004 - New chronology for El Teniente, Chilean Andes, from U/Pb, 40Ar/39Ar, Re-Os and fission track dating: Implications for the evolution of a supergiant porphyry Cu-Mo deposit (in Sillitoe, R.H., Perelló, J., and Vidal, C.E., eds.) Andean Metallogeny: New Discoveries, Concepts and Updates. Society of Economic Geologists, SEG Special Publication 11, 2004, pp. 15-54.
- Ossandón G (1974) Petrografía y alteración del pórfido dacítico, yacimiento El Teniente. Memoria de Título, Depto de Geología, Univ Chile, Santiago.
- Skewes, M.A., Arévalo, A.G., Floody, R., Zuñiga, P., Stern, C.R., (2002). The giant El Teniente breccia deposit: hypogene copper distribution and emplacement. In: Goldfarb, R., Nielsen, R. (eds) Integrated methods for discovery: global exploitation in the 21st Century. Society of Economic Geologists, Special Publication Nº 9, pp. 299-332.

## Río Blanco - Los Bronces

- Alfaro M (1970) Estudio geológico de la mina Los Bronces, Provincia de Santiago. Memoria de Título, Depto de Geología, Univ Chile, Santiago
- Blondel JR (1980) Pórfido de composición granodiorítica de la mina Río Blanco. Memoria de Título, Depto de Geología, Univ Chile, Santiago
- Cuadra W (1980) Geología y petrogénesis de la Brecha Donoso, Mina Los Bronces. Memoria de Título, Depto de Geología, Univ Chile, Santiago
- Davidson, P., Kamenetsky, V., Cooke, D.R., Frikken, P., Hollings, P., Ryan, C., Van Achterbergh, E., Mernagh, T., Skarmeta, J., Serrano, L., and Vargas, R., 2005. Magmatic Precursors of Hydrothermal Fluids at the Río Blanco Cu-Mo Deposit, Chile: Links to Silicate Magmas and Metal Transport. Economic Geology, v. 100, pp. 963–978.
- Deckart, K., Clark, A.H., Aguilar, C., Vargas, R., Bertens, A., Mortensen, J.K., and Fanning, M., 2005. Magmatic and Hydrothermal Chronology of the Giant Rio Blanco Porphyry Copper Deposit, Central Chile: Implications for an Integrated U-Pb and 40Ar/39Ar Database. Economic Geology, v. 100, p. 905-934.
- Frikken, P.H., Cooke, D.R., Walshe, J.L., Archibald, D., Skarmeta, J., Serrano, L., and Vargas, R., 2005. Mineralogical and Isotopic Zonation in the Sur-Sur Tourmaline Breccia, Río Blanco-Los Bronces Cu-Mo Deposit, Chile: Implications for Ore Genesis. Economic Geology, v. 100, pp. 935–961.

- Holgrem, C., Marti, M.; Skewes, M.A.; Schneider, A. And Harmon, R.S., 1988. Análisis isotópicos y de inclusiones fluidas en el yacimiento Los Bronces, Chile central. Actas V Congreso Geológico Chileno, Santiago, Vol. I, pp. B299-B-313.
- Serrano, L.; Vargas, R.; Stambuk, V.; Aguilar, C.; Galeb, M.; Holgrem, C., and Stern, C.R., 1996. The Late Miocene Río Blanco – Los Bronces copper deposit central Chilean Andes. Society of Economic Geologists, Special Publication Nº 5, pp. 119-130.
- Skewes, M.A. y Holgrem, C., 1993. Solevantamiento Andino, erosión y emplazamiento de brechas mineralizadas en el depósito de cobre porfírico Los Bronces, Chile Central (33°S), aplicación de termometría de incusiones fluidas. Revista Geológica de Chile, V. 20, pp. 71-84.
- Skewes, M.A., and Stern, C.R., 1995. Genesis of the giant Late Miocene to Pliocene copper deposits of central Chile in the context of Andean Magmatic and Tectonic evolution. International Geology Review, V. 37, pp. 839-909.
- Skewes MA, Holmgren C, Vargas R (1994) Alteración a anfíbola y magnetita en el megayacimiento Río Blanco-Los Bronces, Chile Central. VII Congreso Geológico de Chile, Concepción, Actas Tomo I:1623-1626
- Skewes MA, Stern CR (1994) Tectonic trigger for the formation of late Miocene Cu-rich breccia pipes in the Andes of central Chile. Geology, V. 22, p. 551-554
- Stambuk, V., 1985. Geología del sector Sur-Sur, yacimiento Río Blanco. Actas IV Congreso Geológico Chileno, Antofagasta, pp. 3-383 – 3-403.
- Vargas, R., Gustafson, L., Vukasovic, M., Tidy, E., Skewes, M.A. (1999). Ore breccias in the Río Blanco-Los Bronces porphyry copper deposit, Chile. In: Skinner, B. (editor) Geology and ore deposits of the Central Andes. Society of Economic Geologists, Special Publication Nº 7, pp. 281-297.
- Warnaars, F.W., 1980. Brechas de cobre y turmalina en Los Bronces, Chile. Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos, Instituto de Ingenieros de Minas de Chile, v.3, p. 175-201.
- Warnaars, F.W.; Holmgren, C. and Barassi, S., 1985. Porphyry copper and tourmaline breccias at Los Bronces – Río Blanco, Chile. Economic Geology, Vol. 80, pp. 1544-1565.

## **Los Pelambres**

- Atkinson, W.W.Jr.; Souviron, A.; Vehrs, T.I.; Faunes, A., 1996. Geology and Mineral Zoning of the Los Pelambres Porphyry Copper Deposit, Chile. In : Camus, F., Sillitoe, R.H., and Petersen, R., eds. Andean Copper Deposits: New Discoveries, Mineralization, Styles and Metallogeny. Society of Economic Geologists, Special Publication Number 5, pp. 131-155.
- Sillitoe, R.H., 1973. Geology of the Los Pelambres porphyry copper deposit. Economic Geology, V. 68, pp. 1-10.
- Skewes, A. and Atkinson, W. Jr., 1985. Petrology of the early formed hydrothermal veins within the central potassic alteration zone of Los Pelambres porphyry copper deposit. Revista Geológica de Chile, Nº. 25-26, p. 39-56.

## Cerro Zaldivar

- Aceituno, J., 2000. Caracterización geológica de la mineralización del yacimiento Zaldivar y su implicancia en el proceso metalúrgico. IX Congreso Geológico Chileno, Actas, V. 1, p. 142-146.
- Maturana, M. y Saric, N., 1991. Geología y mineralización del yacimiento tipo pórfido cuprífero Zaldivar en Los Andes del norte de Chile. Revista Geológica de Chile, V. 18, pp. 109-120.
- Monroy, C., 2000. Nuevos antecedentes geológicos del pórfido cuprífero Zaldivar, II Región, Chile. IX Congreso Geológico Chileno, Actas, V. 1, p. 293-297.

## Chuquicamata

- Alvarez, C.O.; Miranda, M.J. y Guzmán, V.P., 1980. Geología del Complejo Chuquicamata. En: Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos, V. 2, Instituto de Ingenieros de Minas de Chile, Santiago, pp. 314-363.
- Alvarez, O. y Aracena, I., 1985. Algunas consideraciones de la petrología y alteración del complejo plutónico de Chuquicamata, Chile. Actas IV Congreso Geológico Chileno, Antofagasta, V. 4, pp. 1-30.
- Alvarez, O. y Flores, R., 1985. Alteración y mineralización hipógena en el yacimiento de Chuquicamata, Chile. Actas IV Congreso Geológico Chileno, V. 2, pp. 3 78 - 3 100. Antofagasta.
- Alvarez, O. y Guzman, P., 1985. Estimación de recursos y reservas en el yacimiento Chuqui Norte, Chuquicamata, Chile. Actas IV Congreso Geológico Chileno, V. 2, pp. 3 101 - 3 120. Antofagasta.
- Ballard J.R. Palin J. M., Williams I.A. and I a. Cambell, 2001. Two ages of porphyry intrusion resolved for the super-giant Chuquicamata copper deposit of northern Chile by ELA-ICP-Ms and SHRIMP Geology, v. 29, p 383-386.
- Flores, R., 1985. Control del enriquecimiento supérgeno en el yacimiento Chuquicamata, Chile. Actas IV Congreso Geológico Chileno, V. 2, pp. 3 228 - 3 249, Antofagasta.
- Lindsay, D., Zentilli, M., and Rojas, J., 1995. Evolution of an active ductile to brittle shear system controlling mineralization at the Chuquicamata porphyry copper deposit, Chile. International Geology Review, V. 37, p. 945-958.
- Lindsay, D.D., Zentilli, M., and Ossandon, G., 1995. Evolution of Permeability in an Active Ductile to Brittle Shear System Controlling the Mineralization at the Chuquicamata Porphyry Copper Deposit, Chile. In: Clark, A.H., ed., Giant Ore Deposits II, Controls on the Scale of Orogenic Magmatic-Hydrothermal Mineralization. Proceedings of the Second Giant Ore Deposits Workshop, Kingston, Ontario, Canada, p. 57-85.
- Lindsay, D.D., 1997. Structural control and anisotropy of mineralization within the Chuquicamata porphyry copper deposit, northern Chile. Ph.D. Thesis (Doctor of Philosophy), Dalhousie University, Nova Scotia, Canadá, 381 p.

- Lopez, M.V., 1939. The primary mineralization at Chuquicamata, Chile, S.A., Economic Geology, V. 34, N\_6, pp. 674-711.
- Ossandón, G. y Zentilli, M., 1997. El Distrito de Chuquicamata: Una concentración de cobre de clase mundial. VIII Congreso Geológico Chileno, Actas, V. III, Universidad Católica del Norte, Antofagasta, pp. 1888-1892.
- Ossandón, G., Fréraut, R., Gustafson, L.B., Lindsay, D.D. and Zentilli, M., 2001. Geology of the Chuquicamata Mine: A Progress Report. Economic Geology, V. 96, Nº 2, pp. 249-270.
- Rojas, J., y Lindsay, D., 1997. Evolución estructural de Chuquicamata, su relación con la intrusión del pórfido y eventos de alteración-mineralización. VIII Congreso Geológico Chileno, Actas, Universidad Católica del Norte, Antofagasta, pp. 1893-1897.
- Reynolds, P.; Ravenhurst, C.; Zentilli, M. and Lindsay, D., 1998. High precision  $^{40}\text{Ar}/^{39}\text{Ar}$  dating of two consecutive hydrothermal events in the Chuquicamata porphyry copper system, Chile. Chemical Geology, Vol. 148, pp. 45-60.

### **Radomiro Tomic**

- Alvarez, O. y Guzmán, 1985. Estimación de recursos y reservas en el yacimiento Chuqui Norte, Chuquicamata, Chile. IV Congreso Geológico Chileno, Antofagasta, p. 3-101–3-120.
- Arcuri, T., and Brimhall, G., 2003. The Chloride Source for Atacamite Mineralization at the Radomiro Tomic Porphyry Copper Deposit, Northern Chile. Economic Geology, Vol. 98, 2003, pp. 1667–1681.
- Cuadra, P. and Rojas, G., 2001. Oxide Mineralization at the Radomiro Tomic Porphyry Copper Deposit, Northern Chile. Economic Geology, V. 96, Nº2, pp. 387-400.
- Cuadra, P., and Camus, F., 1998. The Radomiro Tomic Porphyry Copper Deposit, Northern Chile. In: Porter, T.M., ed., Porphyry and Hydrothermal Copper and Gold Deposits – A Global Perspective; Conference Proceedings, AMF, Adelaide, Australia, p. 99-109.
- Cuadra, P., Grez, E., y Gröpper, H., 1997. Geología del yacimiento Radomiro Tomic. VIII Congreso Geológico Chileno, Actas, Universidad Católica del Norte, Antofagasta, pp. 1918-1922.
- Cuadra, P., Zentilli, M., Puig, A., and Tidy, E., 1997. Dataciones radiométricas recientes en Radomiro Tomic. VIII Congreso Geológico Chileno, Actas, V. II, pp. 916-919.

### **El Abra**

- Alvarez, O., y Aracena, I., 1982. El Abra; uno de los grandes yacimientos de cobre aún no explorados. Minerales, V. 37, N\_160, pp. 25 36.
- Ambrus, J., 1977. Geology of the El Abra Porphyry Copper Deposit, Chile. Economic Geology, V. 72, pp. 1062-1085.

## La Escondida

- Alpers, C.N. and Brimhall, G.H., 1989. Paleohydrologic evolution and geochemical dynamics of cumulative supergene metal enrichment at La Escondida, Atacama Desert, Northern Chile. *Economic Geology*, V. 84, pp. 229-255.
- Alpers, C.N. and Brimhall, G.H., 1988. Middle Miocene climatic change in the Atacama Desert, northern Chile: evidence from supergene mineralization at La Escondida. *Geological Society of America Bulletin*, V. 100, pp. 1640-1656.
- Ortiz, F., Lowell, J.D., Rojas, N. y Burns, P.J., 1985. Reseña Técnica del Descubrimiento del Yacimiento de Pórfido Cuprífero Escondida, II Región, Chile. IV Congreso Geológico Chileno, Antofagasta, p- 3-703-3-729.
- Padilla, R., Title, S.R. and Pimentel, F., 2001. Geology of the Escondida Porphyry Copper Deposit, Antofagasta region, Chile. *Economic Geology*, V. 96, Nº 2, pp. 307-324.
- Richards J.P., Noble S.R. and M.S. Pringle, 1999. A revised Late Eocene age for porphyry Cu magmatism in the Escondida Area, Northern Chile. *Economic Geology*, V. 94, Nº8, pp. 1231-1247.
- Richards, J.P., Boyce, A.J., and Pringle, M.S., 2001. Geologic Evolution of the Escondida Area, Northern Chile: A Model for Spatial and Temporal Localization of Porphyry Cu Mineralization. *Economic Geology*, V. 96, pp. 271-306.

## El Salvador

- Cornejo, P., Mpodozis, C., Tomlinson, A.J., Rivera, O., and Fanning, M., 1997. El Salvador, Chile Porphyry Copper Deposit Revisited: Geologic and Geochronologic Framework. *International Geology Reviews*, V. 39, p. 22-54.
- Cornejo P, Matthews SJ (2000) Relación entre magmatismo-tectónica y su implicancia en la formación de sistemas de pórfidos cupríferos: yacimiento El Salvador, III Región, Chile. In: Abstr Vol 9th Congr Geológico Chileno, Puerto Varas, 31 July-4 August 2000. Vol 1, p. 184-188
- Gustafson L. B. Orquera W. McWilliams M., Castro. M., Rojas. G., Maluenda J. and M. Mendez, 2001.- Multiple centers of mineralization in the Indio Muerto District, El Salvador, Chile. *Economic Geology*, V. 96, Nº 2, pp. 325-350.
- Gustafson, L.B. and Hunt, J.P., 1975. The Copper Porphyry deposit at El Salvador, Chile. *Economic Geology*, V.70, p. 857-912.
- Gustafson, L.B., and Quiroga, J., 1995. Patterns of Mineralization and Alteration below the Porphyry Copper Orebody at El Salvador, Chile. *Economic Geology*, V. 90, p. 2-16.
- Sheppard, S.M.F., and Gustafson, L.B., 1976. Oxygen and Hydrogen Isotopes in the Porphyry Copper Deposit at El Salvador, Chile. *Economic Geology*, V. 71, p. 1549-1559.
- Watanabe, Y., and Hedenquist, J.W., 2001. Mineralogic and Stable Isotope Zonation at the Surface over the El Salvador Porphyry Copper Deposit, Chile. *Economic Geology*, Vol. 96, 2001, pp. 1775-1797

## Potrerillos

Marsh, T.M.; Einaudi, M.T. and McWilliams, M., 1997.  $40\text{Ar}/39\text{Ar}$  geochronology of Cu-Au and Au-Ag mineralization in the Potrerillos District, Chile. *Economic Geology*, V. 92, p.784-806.

## Quebrada Blanca

Hunt, J.P., 1985. Applied Geology at Quebrada Blanca and Collahuasi, Chile, and in the Future of U.S. Metal Mining. SEG Distinguished Lecture in Applied Geology. *Economic Geology*, V. 80, p. 794-800.

Hunt, J.P., Bratt, J.A., and Marquardt, J.C., 1983. Quebrada Blanca, Chile: An Enriched Porphyry Copper Deposit. *Mining Engineering*, June 1983, p. 636-644.

Hunt, J.P., Munchmeyer, C., Marquardt, J.C., Soto, H., 1980. El Proyecto Quebrada Blanca. *Anales del Congreso del Cincuentenario 1930-1980 Minería de Cobres Porfíricos*, Instituto de Ingenieros de Minas de Chile, v.3, p. 263-289.

## Collahuasi - Ujina

Bisso C., Durán. M. and A. Gonzalez, 1998. Geology of the Ujina and Rosario copper Porphyry deposits, Collahuasi District, Chile. In Porter T. M.(editor) *Porphyry and the Hydrothermal Copper and Gold deposits a Global Perspective Addendum Late Paper*.

Clark, A.H., Archibald, D.A., Lee, A.W., Farrar, E., and Hogson, J., 1997. Laser-Probe  $^{40}\text{Ar}-^{39}\text{Ar}$  ages of early and late stage alteration assemblages, Rosario porphyry copper-molybdenum deposit, Collahuasi District, I Región, Chile. *Economic Geology*, V. 93, p. 326-337.

Dick L.A., Chavez. W.X., Gonzalez A. and C. Bisso, 1994. Geologic setting and Mineralogy of the Cu-Ag-(As) Rosario Vein System , Collahuasi District , Chile SEG Newsletter 19.

Dick, L.A.; Ossandon, G.; Gonzalez, A.; Vega, J. and Echegaray, J., 1994. Geologic setting and Controls on the Development of Secondary Enrichment, Rosario and Ujina Porphyry Cu-Mo Deposits, Collahuasi District, I Region, Chile. *7º Congreso Geológico Chileno, Actas*, V. II, p. 1549-1550.

Masterman, G.J., Cooke, D.R., Berry, R.F., Clark, A.H., Archibald, D.A., Mathur, R., Walshe, J.L., and Durán, M., 2004.  $40\text{Ar}/39\text{Ar}$  and Re-Os Geochronology of Porphyry Copper-Molybdenum Deposits and Related Copper-Silver Veins in the Collahuasi District, Northern Chile. *Economic Geology*, Vol. 99, pp. 673–690.

Masterman, G.J., Cooke, D.R., Berry, R.F., Walshe, J.L., Lee, A.W. and Clark, A.H., 2005. Fluid Chemistry, Structural Setting, and Emplacement History of the Rosario Cu-Mo Porphyry and Cu-Ag-Au Epithermal Veins, Collahuasi District, Northern Chile. *Economic Geology*, v. 100, p. 819-834.

Moore, R.L. and Masterman, G.L., 2002. The corporate discovery and geology of the Collahuasi district porphyry copper deposits, Chile. In: Cooke, D.R. and Pongratz, J., eds., *Giant Ore Deposits: Characteristics, genesis and exploration*. CODES Special Publication 4, Australia, p. 23-50.

