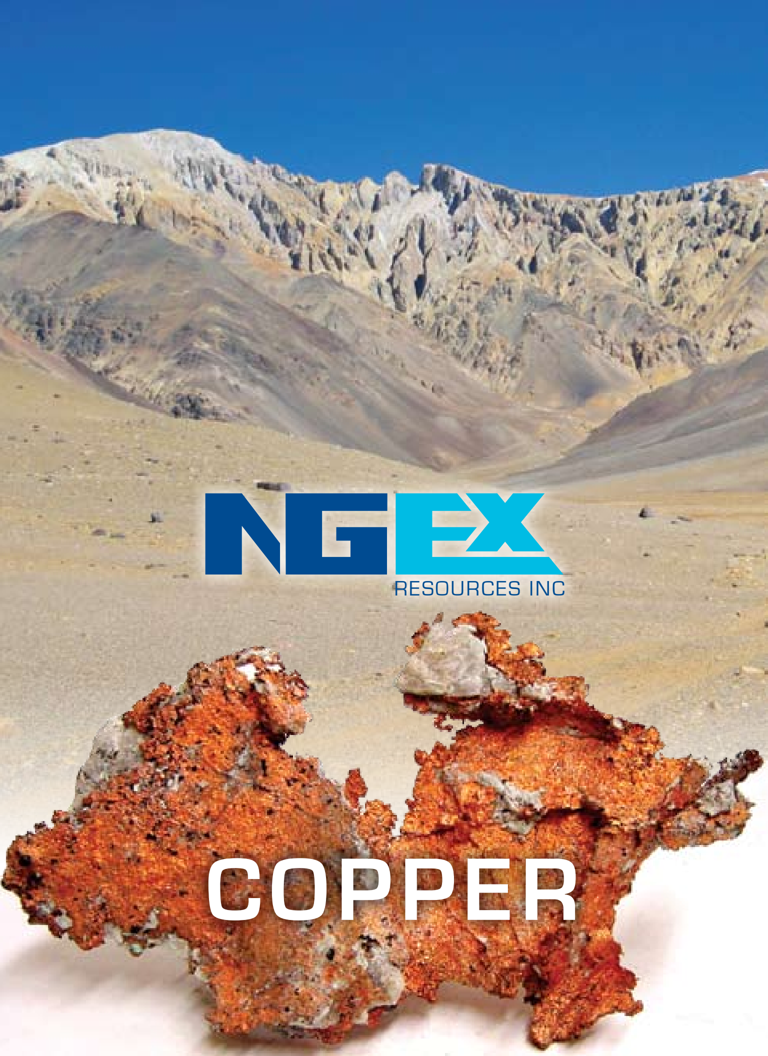


NGEX RESOURCES INC

# COPPER

Symbol ***Cu***
Latin ***cuprum***

photo © Jonathan Zander

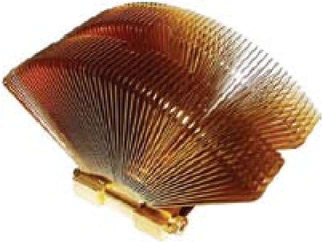
Copper is **100% recyclable** without any loss of quality

An estimated 80% of the copper ever mined is still in use today

Cover photo of native copper © U.S. Geological Survey

In the Roman era, copper was principally mined on Cyprus, hence the origin of the name of the metal as Cyprium, “metal of Cyprus,” later shortened to Cuprum.

Electrical conductor



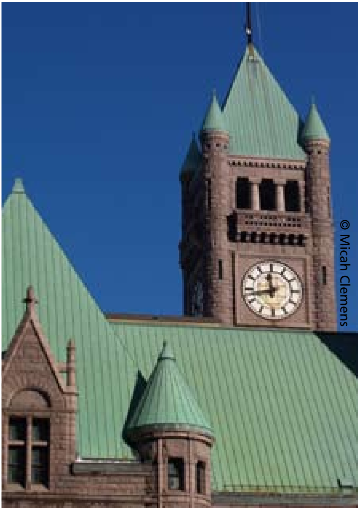
Copper is a thermal conductor

In alchemy the symbol for copper, ♀ was also the symbol for the goddess and planet Venus

# COPPER – THE RED METAL

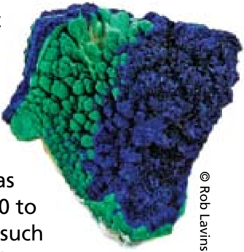
Copper – symbol Cu – is one of the most important of the base metals, with numerous applications in today's highly industrialized world. The name derives from the Latin word *cuprum* (or *cyprium*; *chalkos* in Greek), which describes one of the earliest sources of the metal from mines on the island of Cyprus.

Pure copper is pinkish in colour but is commonly described as the "red metal" due to a thin layer of oxide tarnish that develops on surfaces exposed to the atmosphere. This coating prevents further corrosion of the metal as does the green copper-carbonate patina seen on many exposed pieces of copper art and roof sheeting. Copper belongs to the same family in the periodic table as silver and gold and has similar properties. Copper is malleable, ductile, an excellent conductor of heat and electricity and relatively resistant to corrosion. Copper has the second highest electrical conductivity of all the metals after silver and it can be worked easily into sheets or drawn into wire making it ideal for electrical applications.



© Micah Clemens

# COPPER'S HISTORY



© Rob Lavinsky

Copper has been used by humans for at least 10,000 years, initially due to the fact that it can occur in the native metallic form. The earliest uses of copper were largely limited to the creation of ornaments and jewelry. In Eastern Europe and elsewhere, the smelting of copper from secondary minerals such as malachite and azurite dates from about 5,000 to 6,000 B.C. for the production of simple tools such as chisels, axes and spear heads and, later, coins.

Bronze is an alloy of copper and tin that became increasingly common after 3,000 B.C. in the Middle East. It has a superior hardness to copper alone and gave its name to the Bronze Age, a period of major advance in the development of metallurgy. Bronze was probably originally produced by smelting ores that fortuitously contained both copper and tin. Brass is an alloy of copper and zinc that became widely used during the Roman Empire. Annual Roman copper mining and smelting reached 15,000 tonnes, an output not exceeded until the Industrial Revolution.

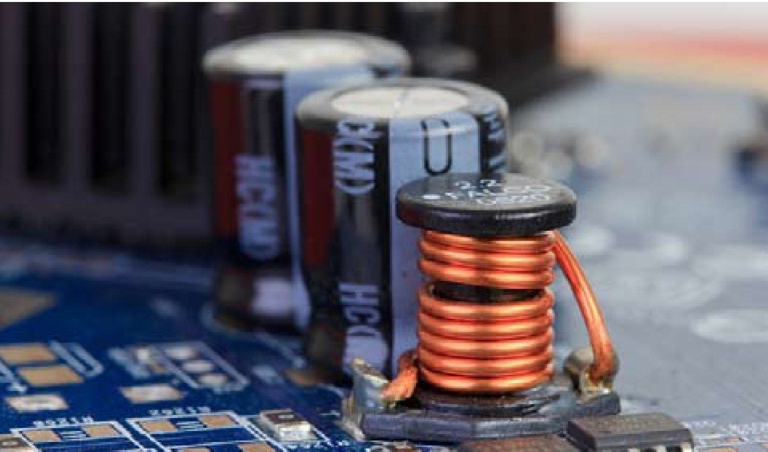
After the fall of the Roman Empire, copper production waned during the Dark Ages. Pre-industrial consumption grew with the increasing use of copper sheathing on ships' hulls as an anti-fouling agent. The Industrial Revolution eventually ushered in copper's crucial applications in the transmission of electricity.

© Zereshk

## CURRENT USES

The physical properties of copper make it ideal for a number of industrial uses including architecture, automotive, electrical, building wire, pipe, plumbing fixtures and telecommunication. Building construction is the single largest market, followed by electronics and electronic products, transportation, industrial machinery, and consumer and general products. Residential construction is about two-thirds of the building construction market. An average single-family home uses 200 kg of copper. The substitution of aluminum as a cheaper and more light-weight alternative to copper in electrical transmission lines has largely been abandoned due to safety and efficiency concerns. Copper wire is used extensively in electrical motors in industrial plants, in generators, turbines and internal combustion engines, especially in hybrid automobiles. The average hybrid car contains about 35 kg of copper, about twice as much as a conventional car.

Copper also has important applications in heat sinks and heat exchangers, as piping for plumbing, refrigeration and air



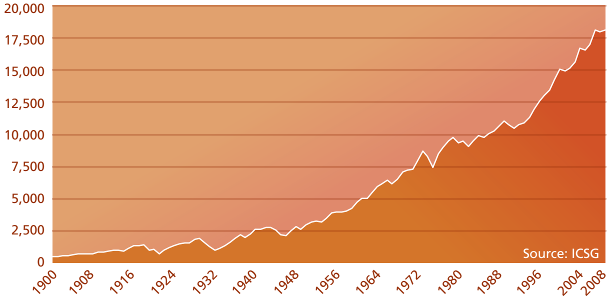
conditioning and, in electromagnets, electrical relays, circuit boards and switches and, last, as roof sheathing, cookware, coins and decorative art wares. There are also applications for copper compounds in ceramic glazes, fungicides and nutritional supplements. Copper's utility is truly extensive and as emerging markets such as China industrialize, their use of copper will dramatically increase.

Copper has been described as the "metal with a PhD in economics," a reference to the fact that it is such a key component of so many industrial products that its growth in usage is driven by global industrialization and is a proxy for economic growth in general. Therefore growth in copper demand translates into substantially improved standards of living for people in a host of emerging nations.

The global consumption of copper has increased exponentially since the early 1900's and has essentially tracked the industrialization of the global economy. The consumption of copper has increased from less than 500,000 tonnes per year in 1900 to 18 million tonnes per year in 2009 as demand grew an average of 4% per year.

**World Refined Copper Usage, 1900-2009p**

thousand metric tonnes

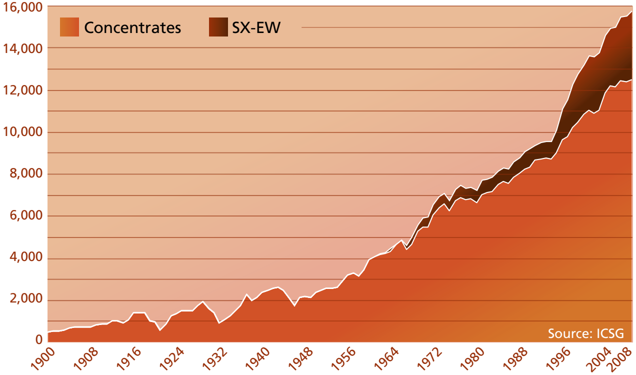


Source: ICSG

# PRODUCTION

The global production of copper has increased exponentially since the early 1900's. Annual production has increased at an average rate of 4% a year from less than 500,000 tonnes in 1900 to 15.7 million tonnes in 2009.

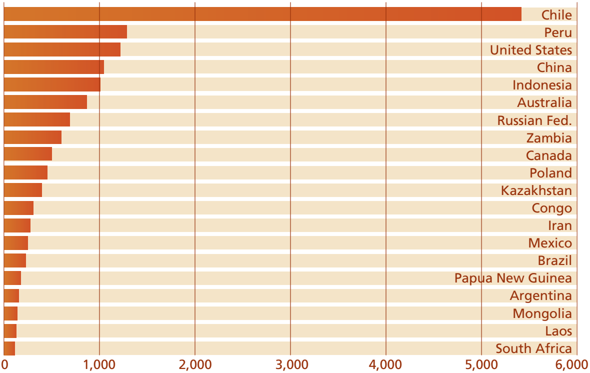
**World Copper Mine Production, 1900-2009p**
thousand metric tonnes



Since 1900, when world production was less than 500 thousand tonnes, world copper mine production has grown by around 4% per y ear to reach nearly 16 million tonnes in 2009. SX-EW production, virtually nonexistent before the 1960's, reached nearly 3.3 million tonnes in 2009.

Chile is by far the world's largest miner (2009: 5.4 million metric tonnes) and exporter of copper. It is also the third largest smelter and second largest refiner of copper. The relentless increase in the use of copper is indicative of the accelerating growth of emerging economies, notably the BRIC's (Brazil, Russia, India and China) among numerous others.

**Copper Mine Production by Country: Top 20 Countries in 2009p**
thousand metric tonnes



Chile accounted for over one-third of world copper mine production in 2009 with mine output of nearly 5.4 million tonnes.

## PORPHYRY COPPER DEPOSITS

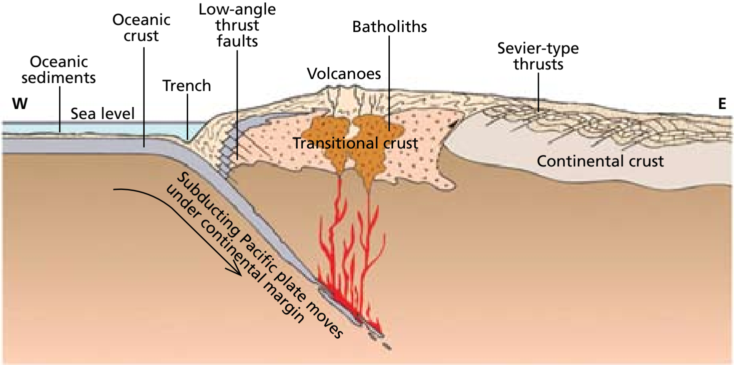
Copper is produced mainly from three principal types of deposit and miscellaneous others:

- Porphyry copper-(molybdenum)-(gold) deposits, including skarns and some iron-oxide, copper-gold (IOCG) deposits (55-60% of world output);
- Sediment-hosted deposits (25% of world output);
- Volcanogenic massive sulphide (VMS) deposits (15% of world output);
- Minor, small vein-type deposits (<5% of world output).

Porphyry copper deposits are the single largest source of copper in the world and account for almost all copper production in

Chile. The term "porphyry copper" derives from exploration in the SW USA in the 1940s and 1950s, which identified large, low-grade, "disseminated" copper deposits associated with **porphyritic**, felsic ("granitic") intrusive stocks and dikes. Such deposits are amenable to low-cost, bulk mining by open-pit or underground block-caving methods.

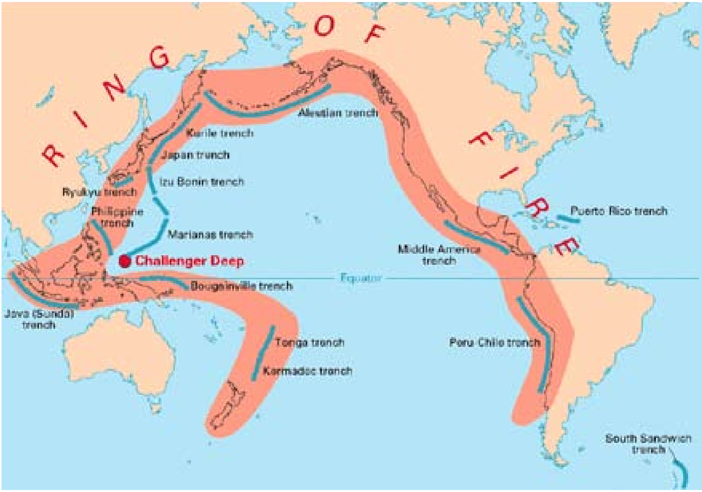
Porphyry copper deposits form in response to collisional plate tectonics processes, whereby a basaltic oceanic plate about 15 km thick flows outward like a conveyor belt from a mid-oceanic



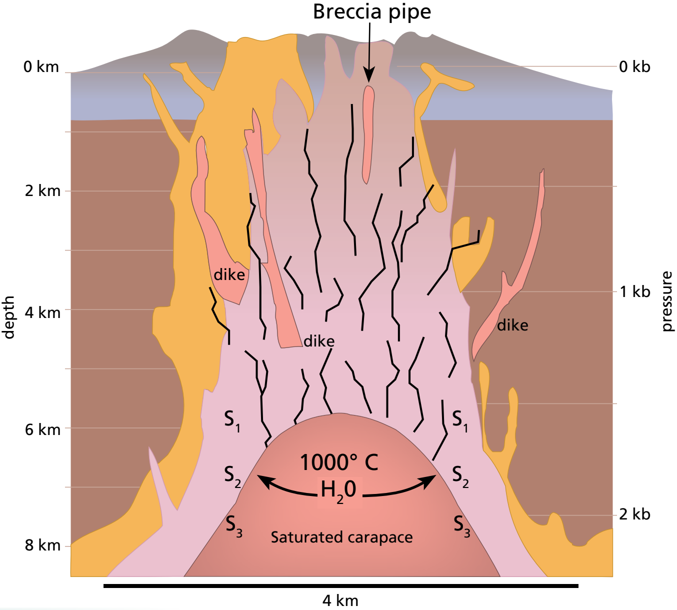
spreading centre and subducts, or dives, under a continental margin. The dense oceanic plate moves slowly down a subduction zone beneath the less-dense continent at angles ranging from -30° to -60°, carrying with it large slabs of the overlying seawater-bearing sediments.

The west coast of South America is an excellent example of a continental margin underlain by an active subduction zone on the eastern side of the so-called "Ring of Fire."

At depths of 60-80 km, crustal melting begins to occur in the subduction zone, generating huge magmatic bodies that begin to migrate towards the surface, like giant bubbles. As they rise, these high-temperature magmas begin to assimilate wall rocks and the metals they contain, including copper, gold, silver, molybdenum, among others and also sulphur. Importantly, the magmas are rich in oxygen, which prevents sulphur from com-



bining with the economic metals to form sulphides in a weakly disseminated, non-economic deposit. Instead, in combination with water, magma-soluble, metal-sulphur-hydroxide-oxide complexes form, which become progressively concentrated in the upper, more felsic parts of the magma. As the magma moves higher in the crust, cooling occurs, giving rise to fractionation, whereby dense, more mafic silicate minerals (pyroxenes, calcium-rich plagioclase feldspars) crystallize and sink to the bottom of the magma chamber. In this manner, the magma becomes steadily less dense (more buoyant), more felsic (higher in silica – $SiO_2$ or more"granitic" in composition) and progressively enriched in important economic metals such as copper.



Higher in the crust, smaller intrusions separate from the main magma bodies and rise toward the surface, erupting in places to build strata-volcanoes. At depths of three-to–five kilometres below the surface, crystallization and cooling (to about 600-700°C) of the felsic magma reaches the stage where a metal-sulphur-silica-chloride-rich hydrothermal fluids separates and migrates rapidly upward along multiple fractures and faults developed in a broad zone above the shallower plutons. The rapid formation of a buoyant hydrothermal fluid may also lead to the generation of complex breccias bodies, which are commonly well mineralized. The highly reactive hydrothermal fluid causes extensive alteration of the wall rocks and deposits a variety of copper-sulphide (and other – Mo, Au, Ag, Pb, Zn) minerals over a broad area and vertical interval in ramifying fractures and quartz veins (quartz stockwork) as the fluids cool through a range of 300°-450°C. Repeated episodes of high-level intrusion, hydrothermal alteration and metal deposition can generate very large and rich porphyry deposits and their related high-level epithermal gold-silver deposits. In this way, many porphyry-copper-(molybdenum)-(gold) deposits are born inboard of the continental margin.

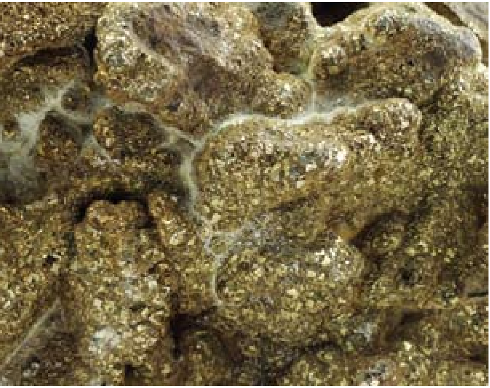
The partly metal-depleted hydrothermal fluids continue upward along structural conduits and deposit any remaining gold and silver (and minor accessory copper, arsenic, lead, antimony, bismuth, molybdenum, etc.) as complex sulfosalts and pyrite in high-level, low-temperature (<250°C), epithermal deposits one-to-two km above the copper porphyry environment. The main mechanism for metal deposition is boiling of the hydrothermal fluids at shallow depths below the surface. These deposits are generally low in gold grade (1-2 g/t Au but with high-grade “bonanza” zones) but can be very large (i.e. Veladero in Argentina and Yanacocha in Peru). They commonly occur in volcanic rocks that are genetically and temporally related to the much deeper parent magmas from which the copper porphyry deposits evolved.

Such so-called high-sulphidation, epithermal deposits are typically extremely silica rich and are characterized by an “advanced-argillic” alteration assemblage composed of alunite ($KAlSO_4$) and the clay minerals pyrophyllite, dickite, diaspore and kaolinite. Their shallow level of formation leads to the rapid oxidation of the sulphide and sulfosalt minerals and the liberation of gold and silver. Oxide precious-metal deposits can be heap leached to recover gold and silver at low cost.

As a final comment, it is to be noted that the process of subduction extends over tens of millions of years. Active subduction zones may be abandoned and new ones spontaneously formed further seaward from the continental margin. Such renewal and migration of subduction zones commonly gives rise to several generations, or ages, of porphyry copper deposits in parallel belts together with their related, higher-level, epithermal gold-silver deposits.

## ALTERATION MINERALS AND ZONES

Hydrothermal alteration minerals form in distinct zones in a porphyry deposit. Potassic (potassium feldspar and/or biotite mica) alteration comprises the core zone of the deposit, commonly associated with hydrothermal magnetite or hematite and chalcopyrite/bornite > pyrite. Phyllic alteration is characterized by quartz-sericite



(fine-grained muscovite mica)-pyrite-(chalcopyrite) and forms an extensive zone surrounding and above the potassic zone. The uppermost alteration zone above a deep, buried porphyry is advanced argillic, comprising silica and the clays pyrophyllite, dickite, diaspore and kaolinite, and is associated with high-sulphidation gold deposits. Repeated late pulses of phyllic alteration, which is acidic chemically, may overprint earlier-formed mineralized zones and result in the leaching of previously deposited copper minerals. A low-temperature propylitic alteration zone (chlorite, epidote, calcite +/- minor pyrite) can extend outwards from the phyllic zone for some kilometres in big mineralized systems. Overall, the large alteration foot print provides a key means by which geologists can identify potential porphyry systems in the field.

## PORPHYRY COPPER MINERALIZATION

The most common primary ore minerals in porphyry deposits are the copper sulphides chalcopyrite ($CuFeS_2$ – 34% copper) and bornite ($Cu_5FeS_4$ – 63% copper). Pyrite ($FeS_2$) is ubiquitous, especially in the upper parts of porphyry deposits. Copper grades in primary hypogene porphyry ores range from 0.2% to 1.0% Cu with variable amounts of accessory molybdenum, gold and silver. Deep bornite-dominant zones constitute high-grade ore in some porphyry systems. Sulphides of lead (PbS – galena) and zinc (ZnS – sphalerite) are commonly found in peripheral veins, distal to the copper-porphyry core.

The surface weathering of pyrite in the upper levels of porphyry deposits can generate sulphuric acid ($H_2SO_4$), which attacks copper-bearing sulphides and dissolves copper. Under the right conditions, the dissolved copper moves down to the water table where it precipitates on pyrite grains as chalcocite ($Cu_2S$ – 80% copper), the beginnings of a process known as supergene enrichment. In the semi-arid Altiplanos of Chile, progressive, slow erosion, sulphuric acid generation and a falling water table over millions of years have led to substantial, enriched (high grade) copper deposits. Such copper deposits are essentially hidden under a leached, copper-deficient cap 100 metres or more thick and are difficult to discover. The best Chilean example is Escondida, a huge, enriched copper deposit, whose name means “hidden” in Spanish.

Porphyry copper deposits with a low content of pyrite may weather near surface to a variety of secondary oxide, carbonate and sulphate minerals, without enrichment. Such deposits may be mined by open pit and processed by heap leaching using dilute sulphuric acid to dissolve the copper. The copper in solution is recovered by solvent extraction-electro-winning to produce cathode copper.

## EXPLORATION FOR PORPHYRY COPPER DEPOSITS

New models of porphyry-copper deposits have evolved in the last 30 years or so. Early models envisaged porphyry copper deposits forming as a result of hydrothermal cells circulating very high in the Earth’s crust adjacent to intrusive magmatic bodies and leaching copper from the wall rocks. As a consequence, porphyry deposits were thought to have shallow roots of several hundred metres at most and were not worthy of deep exploration.

However, a number of copper porphyries, especially gold-bearing ones, have proven to have very deep roots extending well over a range of one kilometre vertically. These discoveries changed the exploration model for porphyries due to the recognition that copper and other economic metals are accumulated in magmas at very great depths in the Earth’s crust.

There are numerous exploration methods that can be applied to copper porphyries, ranging from basic prospecting and geological mapping in well exposed regions, to stream, soil and rock geochemistry and airborne and ground geophysics. In mountainous Chile, where there is good rock outcrop, multi-spectral Landsat imagery provided by satellites offers an excellent preliminary tool to select potentially prospective areas exhibiting strong colour anomalies derived from alteration minerals, principally various clays and iron oxides.

Porphyry copper deposits contain large volumes of disseminated sulphides, which respond well to induced polarization (IP), a ground electrical technique employing very-low-frequency alternating current inputs into the ground. Magnetite is a common alteration mineral in the core of many porphyry deposits

and can be identified by both airborne and ground magnetic surveys. There are other electric and electro-magnetic methods that are effective exploration tools.

The defining of a porphyry deposit relies on extensive drilling, using both core and reverse circulation methods. The amount of drilling required to define an ore body to NI43-101 standards depends on many factors, including variability of copper grades, sulphide mineralogy and metal recoveries across the deposit. Normally, the drill definition of a porphyry-copper deposit requires hundreds of holes amounting to many tens of thousands of metres and tens of thousands of multi-element assays, costing many millions of dollars.

## RESOURCES, RESERVES AND FEASIBILITY STUDIES

Detailed drilling and assays allow for the determination of mineral resources and reserves according to industry- and government-established standards (for example, CIMM and NI43-101 in Canada). Specialized computer programs are used to generate block-model resources and reserves. Block models are built upon a large number of small blocks, typically 20x20x20 metres on a side, within the limits of the deposit. Each block is assigned a copper grade based upon its spatial relationship to nearby drill holes. Special statistical methods (i.e. kriging) can be applied to the block model to accommodate the unique grade-distribution characteristics of any particular deposit. The sum total of all the blocks generates a resource and/or reserve tonnage and grade for the deposit. At a density of drilling specific to each porphyry deposit, a drill-indicated reserve is generated that forms the basis for a feasibility study.

A feasibility study examines a host of factors that combine to determine the economic viability of a porphyry copper project.

Key variables in determining capital and operating costs of a mine-mill complex include the deposit size, ore grades, ore types, forecast metal prices, planned production rates, mining method and strip ratios, metallurgical characteristics of the ore (plant flow sheet), power and fuel costs, blasting costs, reagent costs, tailing disposal, transportation costs, environmental requirements, net smelter returns, tax rates and others.

The cost of a feasibility study for a large porphyry copper project will amount to several tens of millions of dollars.

## ECONOMIC EVALUATION OF PORPHYRY DEPOSITS

Mineral deposits typically are evaluated on the basis of discounted-cash-flow (DCF) models, also referred to as discounted-cash-flow rate of return (DCF-ROR). Based on the feasibility study, capital plant investments, a negative cash input for mine construction, etc, are offset by a string of positive annual cash flows from the profitable operation of the mine/mill complex over its lifetime. Exploration and feasibility study cash inputs are normally considered sunk costs, are not recoverable in any circumstances if the mine development does not proceed and are ignored for the purpose of the DCF evaluation exercise.

Future cash flows from operations are discounted to the present day at an appropriate interest rate that reflects prevailing financial conditions. The discount rate reflects the reality that a dollar earned today is worth much more than a dollar earned 10 years in the future. Recent and current discount rates are low by historical measures due to low financing interest rates and low inflation. Today, a reasonable discount rate might be 5%. Project DCF models can also be generated assuming constant dollars, that is, zero inflation.

An economic porphyry-copper project will have a positive net present value (NPV) when all of the cumulative, annual cash flows are discounted back to year zero and offset against the initial capital investment. Higher NPVs imply more robust projects that can withstand economic downturns, especially periods of weak metal prices, and are more likely to receive bank financing. The internal rate of return (IRR) is the interest rate at which the NPV of the mining project is zero. An economic project will have an IRR substantially higher than the discount rate.

Project sensitivities are examined by “what if” scenarios that take account of increases and decreases of project inputs, typically 10-20% changes in capital costs, labour costs, and metal prices. Mining project economics are normally most sensitive to changes in metal prices.

A key factor affecting the viability of the project is the pay-back period. Two projects could have the same DCF rate of return but different pay-back periods, due to differing ore grades in the early years of the mining operation, when the project is most at risk of loan default. It is an advantage to be able to mine high-grade ore in the early years of a project.

## MINING AND ORE PROCESSING

Most porphyry deposits are mined by open pit using trucks and shovels. Copper ore is blasted on benches (typically with 18 m (60 foot) raises) in the pit and loaded by shovel into large (up to 250 tonne-capacity) off-road trucks for haulage to the mill. Where circumstances allow, underground block caving is a cost-effective method for mining deep, bulk-mineable ore bodies.

After ore has been mined, it is crushed and ground and then the ore minerals are separated from the rock by either sulphide flotation where primary sulphide ores are to be treated or by heap leaching and solvent extraction and electro-winning (SX-EW) where acid soluble secondary oxide, carbonate and sulphate ores are involved.

In froth-flotation plants, a sulphide concentrate is produced, normally grading approximately 30% copper or better depending on the make-up of the copper sulphide minerals in the ore body. Co-products like molybdenum are recovered as separate concentrates. Gold and silver, if present in the ore, generally report to the copper concentrate. The concentrate is shipped to a smelter, which charges a fee for treating the material and also imposes penalties for excessive amounts of deleterious metals, for example arsenic and selenium. Gold and silver in the concentrate are credited to the mine by the copper smelter. After all smelting costs have been deducted, the mine receives payment, termed a net smelter return (NSR), from the smelter.

In the case of oxide ore, copper is extracted through heap leaching of the ore with dilute sulphuric acid. SX-EW processing of oxide copper ores offer the advantage of producing copper metal at the mine site, thereby minimizing transportation costs and maximizing copper revenues. The disadvantage is that precious metals and other metals are not recovered. In the process, the ore is placed in heaps over an impermeable liner and sprayed with dilute sulphuric acid, which dissolves the copper. The copper bearing solution (pregnant solution) is piped to an SX-EW plant where the copper is stripped by an organic solvent. High-purity cathode copper is then produced in an electrowinning cell.


Copper Zone
N
681 m @ 0.26% Cu
incl. 61 m @ 0.51% Cu
711 m @ 0.54% Cu
Porphyry system
465 m @ 0.4% Cu
416 m @ 0.2% Cu
and 182 m @ 0.32% Cu
701 m @ 0.67% Cu
313 m @ 0.24% Cu
456 m @ 0.51% Cu
incl. 112m @ 0.63% Cu
LH-15
OPEN
655 m @ 0.26% Cu
incl. 46 m @ 0.56% Cu
LH-14
728 m @ 0.47% Cu
Incl. 210 m @ 0.61% Cu
LH-22
430 m @ 0.46% Cu
LH-12
LH-20
216 m @ 0.70% Cu
LH-21
LH-16
LH-17
312 m @ 0.72% Cu
Incl. 108 m @ 0.86% Cu
LH-23
Higher grade
OPEN
LH-13
575 m @ 0.58% Cu
incl. 197 m @ 0.71% Cu
LH-24
728 m @ 0.55% Cu
incl. 146 m @ 0.67% Cu
LH-19
LH-18
762 m @ 0.43% Cu
incl. 343 m @ 0.58% Cu
414 m @ 0.35% Cu
OPEN
530 m @ 0.5% Cu
incl. 114 m @ 0.6% Cu
562 m @ 0.54% Cu
incl. 212 m @ 0.68% Cu
468 m @ 0.55% Cu
306 m @ 0.4% Cu
incl. 128 m @ 0.5% Cu
52 m @ 0.5% Cu
558 m @ 0.48% Cu
Incl. 92 m @ 0.87% Cu
Chile
● 2011 hole
○ short hole
Argentina
1 km

# THE CHILE EXPERIENCE

Chile is the Saudi Arabia of copper. Due to a unique combination of geology, climate, and politics it is the world's largest producer of copper accounting for approximately 35% of world production – almost all of it from porphyry deposits. Chile also possesses the largest copper reserves in the world. Chile's amazing endowment of copper (think Escondida, Chuquicamata, El Teniente and others) derives from its position on a subduction zone that has been active for most of the last 100 million years. The Chilean subduction zone is part of the circum-Pacific "Ring of Fire," a belt of (mostly) active subduction that extends tens of thousands of kilometres along the entire length of the cordilleras of western South and North America, the east coast of Siberia, through Japan and into the archipelagos of the Philippines and Indonesia. There are other important porphyry-copper belts but the Ring of Fire is the most renowned and most productive and Chile is the most productive segment of the Ring of Fire.

# NGEX'S ADVANCED PROJECTS

NGEx has been active in one corporate form or another in Chile and Argentina for some 20 years. Currently, it is actively exploring several copper-gold projects in central-northern Chile and bordering Argentina. Three advanced porphyry-copper-(gold) projects, Los Helados, Filo del Sol and Josemaria, are joint ventures with JOGMEC (Japan Oil, Gas and Metals Exploration Company), a Japanese state-funded company, as to 60% NGEx and 40% JOGMEC.

The projects are accessible by road from the city of Copiapo, about 90 km to the west, and straddle the border between Chile and Argentina. The projects lie midway between the Maricunga copper belt 150 km to the north and the Veladero/El Indio gold belt 100-150 km to the south.

Los Helados shows good potential to be a major copper-gold deposit. Of particular interest at Los Helados is a zone of higher grade copper and gold mineralization associated with quartz-feldspar porphyry and hydrothermal breccias. This higher grade mineralization is associated with potassic alteration and remains open below 750 metres depth.

Josemaria is located in the province of San Juan, Argentina near the border with Chile. It contains a resource of 460 million metric tons grading 0.40% Cu and 0.30 g/t Au. JOGMEC is in the process of earning a 40% interest in the project by spending US$6.1 million by 2012. Current drilling is seeking to expand the deposit under younger cover to the north and east, where significant geophysical anomalies (IP) have been identified.

Filo del Sol straddles the Chile-Argentina border. It comprises a large, high-sulphidation gold system overprinted on a deeper porphyry copper deposit. A significant resource of calcanthite (a water-soluble copper sulphate – $CuSO_4.5H_2O$) grading about 0.40% Cu could be recovered by simple leaching. Otherwise, the property constitutes a major zone of alteration, of which only about one-third has been tested by drilling.

## PROJECTS IN THE PIPELINE

NGEx has three promising copper porphyry projects that are at an early stage of exploration – Colmillos, Andrea, and Paramillos.

Colmillos and Andrea lie within the Central Chile cordillera in the Eocene-Oligocene (56 million to 23 million years old) copper belt.

Colmillos is situated south of the El Indio epithermal gold belt. It consists of a large body of tourmaline breccia ($Na(Mg,Fe)_3Al_6(BO_3)_3(Si_6O_{18})(OH)_4$ – a mineral indicating boron (B) alteration or metasomatism) lying within a larger area of strong phyllic and advanced argillic alteration. Copper and molybdenum are strongly anomalous geochemically (292 parts per million (ppm) Cu and 45 ppm Mo) in talus and rock samples over a length of 1.2 km.

Andrea is situated 100 km south of Colmillos. A potassic alteration zone carrying pyrite, magnetite and chalcopyrite crops out in the central part of the property and is surrounded by a large area altered to sericite and iron oxides. Rocks in the central potassic zone grade an average of 0.18% Cu (individual samples up to 0.60% Cu) and 30 ppm Mo over an area of 0.8 km$^2$. The property is believed to host a major porphyry copper-molybdenum-(gold) system.

Paramillos is a large, under-explored porphyry copper system located in the province of Mendoza, Argentina. It was identified by the UN in the 1960’s as a high-priority copper target and is characterized by a prominent leached stockwork zone. Mendoza has been a difficult province for mineral exploration and mining but legal issues are being resolved.

# DICTIONARY OF GEOLOGICAL TERMS

**Hydrothermal fluid:** Hot metal bearing fluid responsible for mineralization.

**Igneous rock:** A rock that was once molten. Volcanic – cooled at the surface. Intrusive – cooled deep in the earth.

**Stock:** General term for a body of intrusive rock. Often has pipe-like geometry.

**Porphyry:** An igneous rock that contains large crystals in a fine crystalline matrix. A porphyritic texture tells geologists that the rock experienced slow cooling (big crystals) followed by very fast cooling (fine crystalline matrix). This is important because the fast cooling may be caused by the explosive release of metal bearing hydrothermal fluids which often break the rock, forming veins and breccias – see below.

**Vein:** Thin crack in rock typically containing ore minerals. Veining in porphyries is caused by release of hydrothermal fluids see above. A mass of cross-cutting veins is called a stockwork.

**Breccia:** A rock composed of angular broken rock fragments held together by mineral cement and fine grained matrix. Often hosts higher grade mineralization.

**Hydrothermal alteration:** Any change in the chemical and mineralogical composition of a rock caused by hydrothermal fluid. Recognition and mapping of hydrothermal alteration is a key step in the exploration process.

**Potassic:** Alteration consisting of potassium bearing minerals like K feldspar and biotite. Forms early and is characteristic of the deeper, hotter, higher grade core of a porphyry system.

**Phyllic:** Alteration consisting of quartz, sericite, chlorite, and pyrite. Typically overprints earlier potassic alteration. Characteristic of intermediate levels of the system.

**Advanced Argillic:** Alteration consisting of silica and various high temperature clays. Late characteristic of the upper levels of the system. Characteristic alteration of high-sulfidation gold systems – see below.

**Propylitic:** Alteration consisting of chlorite, epidote. Distal equivalent of potassic alteration. Forms a broad halo around porphyry systems that may extend for many kilometers from center.

**Porphyry copper:** A type of copper deposit characterized by a very large (100Mt to >10 Bt) volume of disseminated mineralization occurring in stockwork veins and breccias. So called because mineralization is genetically associated with porphyritic stocks. Globally the most important type of copper deposit. Accounts for almost all of Chile’s production. Classic examples include Escondida, Chuquicamata, El Teniente, Morenci, Grasberg.

**High-sulfidation gold:** A type of gold deposit characterized by a large volume of disseminated gold mineralization. Associated with advanced argillic alteration. Forms in the upper part of a porphyry copper system. The most important type of gold deposit in South America. Classic examples include Yanacocha, Pierina, Pascua-Lama, Veladero.

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