

Porphyry Deposits Winning Even Precious Metal Respect

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TORONTO ([ResourceInvestor.com](http://www.ResourceInvestor.com)) -- The rise in metal prices since the lows of 2001 has renewed interest among producers, explorers and investors in the largest copper deposits on Earth - porphyry copper deposits. Yet the interest is not limited to just **copper** as these deposits can potentially host significant concentrations of **gold**, **silver** and **molybdenum**, an element used in hardening steel.

Moly prices doubled in 2004, whilst copper recently reached a 16-year high in New York, and gold and silver prices have averaged more than we've seen in a decade. Consequently, the imputed value per tonne of porphyry deposits has rocketed making them the target of cash flow and growth hungry companies.

The interest is not just limited to base metal companies since gold companies with some natural hedging exposure have been some of the best investments in this cycle.

Ivanhoe Mines's [IVN] Oyu Tolgoi deposit is perhaps, from a resource investor perspective, the most important copper and gold porphyry presently being developed anywhere in the world. It is well above average grade for deposits of this type, and investors now wait to see if it can become the cash dispensing machine that the world's greatest mine, Grasberg, is. Grasberg is owned by **Freeport McMoRan** [FCX] and **Rio Tinto** [RTP].

Geology

Porphyry copper deposits can be boiled down to the economics of bulk mining. They are the quintessential low-grade, large-tonnage deposits, containing hundreds of million tonnes of ore generally grading 0.5% copper and up.

Most are Mesozoic to Cenozoic in age and located at convergent plate boundaries in the **Canadian Cordillera**, the **southwest United States**, the **Andes Mountains** in South America, and in the **Philippines**, **Indonesia** and **Papua New Guinea**.

Their occurrence is linked to the intrusion of subduction-related magmas at shallow levels in the crust, generally forming stocks with large, well-formed minerals crystals set in a groundmass of finer-grained crystals, hence the name porphyry. These intrusive rocks are generally felsic to intermediate in composition, ranging from granite to diorite. Virtually any type of country rock can be mineralized and both the intrusion and the country rock typically exhibit pervasive fracturing and brecciation. Copper generally occurs in chalcopyrite in stockworks of veins and disseminated throughout the host rocks.

Porphyry deposits are known for the development of immense (up to 10 km²), convective hydrothermal systems in and around the intrusions. The concentric alteration shells in porphyry copper systems was documented by Lowell and Gilbert in 1970 and has since become required knowledge for a generation of geologists. Their model consists of an inner potassic zone with biotite and potassium feldspar, grading outwards into the phyllic zone (quartz and sericite), passing into the propylitic zone (chlorite, epidote, calcite) and finally an outer argillic zone (clay minerals). Though the Lowell-Gilbert hydrothermal model has proved itself to be an aid in exploration efforts, not all zones are present in every deposit, nor are they always concentric.

Low-temperature processes that are not related to the primary magmatic-hydrothermal system have made many porphyry deposits economical by further concentrating copper. These 'supergene' deposits form from ground water leaching copper from chalcopyrite and re-depositing it as higher-grade chalcocite and bornite below the water table. An oxidized or 'leached' cap is left at the surface, consisting of clay minerals, iron oxides and residual quartz.

Processing

Due to their low grades, porphyry deposits must be amenable to **bulk mining methods** (open pit and, rarely, underground block caving). In very general terms, sulphide ore is concentrated via traditional flotation processes and shipped to smelters, whereas oxide ore is leached to produce a solution that is then subjected to a solvent extraction and electrowinning process (SX/EW), producing copper cathode on site.

Sulphide ores may also undergo bioleaching and/or biooxidation processes that use iron and sulphur oxidizing bacteria to make ores amenable to SX/EW or to directly produce copper.

A joint venture between **BHP Billiton** [BHP] and **Codelco**, the Chilean state copper mining firm and the world number one producer of the metal, is seeking environmental approval for its proposed \$328 million copper bioleaching project that is expected to produce about 153,000 tonnes of the red metal a year.

Though SX/EW is less costly, the electrowinning process is power intensive, an issue in remote locations where power has to be generated at site. High natural gas prices caused **Argentina** to curb exports to **Chile** in 2004, forcing miners there to switch to more expensive energy sources.

Companies and their deposits

The two largest copper porphyry deposits on Earth – **El Teniente**, which also holds the title of the largest underground mine, and **Chuquibambilla** – belong to Codelco.

The state-owned company produced 1.84 billion short tons in 2004 at a cash cost of \$0.37 a pound, making it one of the lowest cost producers. Codelco plans to increase output to meet growing Chinese demand and has added about 73% to its debt since 2001, though its local currency debt outlook was lowered on May 4 by Standard & Poor's to negative from stable.

Title of the world's largest copper producing mine goes to Chile's **Escondida** mine, a joint venture between BHP Billiton (57.5%), Rio Tinto (30%), a consortium of Japanese companies (10%) and the **World Bank's International Finance Corp.** (2.5%). Almost 1.25 billion tonnes were produced from the mine in 2004.

BHP Billiton also owns the **Tintaya** mine in Peru, while Rio Tinto operates the historic **Bingham** mine, 20 miles southwest of Salt Lake City, through its **Kennecott Utah Copper** subsidiary.

Title of the most gold-rich porphyry copper deposit goes to the **Grasberg** mine on the south side of **Papua** (formerly Irian Jaya), Indonesia.

Freeport owns 85.9% of the mine, with the remaining held by the Indonesian government and a private company; Rio Tinto has a claim of 40% of production in excess of 125,000 tonnes per day.

In 2003, 1.5 billion pounds of copper and 2.3 million ounces of gold were produced. The net cash production cost for the copper was negative \$0.02 per pound thanks to the sale of gold as a byproduct credit. Production was down in 2004 due to two pit wall failures: one in October 2003, the other in January 2004. Over 335 million pounds of copper and 600,000 ounces of gold were recovered in this year's first quarter at a cash cost of only US\$0.07 per pound. Freeport McMoRan's share of estimated recoverable reserves at Grasberg as of December 31, 2004 totaled 40.7 billion pounds of copper and 46.6 million ounces of gold.

Another gold-rich porphyry is **Ok Tedi**, situated in the Star Mountains region of Papua New Guinea. In 2004, 173,400 tonnes of copper and 524,500 ounces of gold were produced at the mine at total costs of US\$0.60 per pound of copper. **Inmet Mining** [TSX: IMN] has an 18% stake in Ok Tedi, with the rest held by the federal and provincial governments.

Ivanhoe Mines currently produces copper at its **Monywa** project in **Myanmar**. However, Robert Friedland's company is far better known for its wholly owned Oyu Tolgoi, or **Turquoise Hill**, project in southern **Mongolia**, 550 km due south of the capital, Ulaanbaatar, and 80 km north of the Chinese border. As of the beginning of May, the porphyry deposit has a measured and indicated resource of 32.9 billion pounds of copper and 17.3 million ounces of gold.

Other Producers

Phelps Dodge [PD] produced over a million tons of copper and 57 million pounds of molybdenum in 2004 from a number of porphyry deposits, including **Morenci** (Arizona), **Cerro Verde** (Peru), **El Abra**, and **Candelaria** (Chile).

Collahuasi, a joint venture between **NorandaFalconbridge** [NRD] (44%), **Anglo American** [AAUK] (44%) and a Japanese consortium (12%), produced over 200,000 tonnes of copper concentrates and cathode in 2004. The mine, located in northern Chile, is the fourth-largest worldwide.

Southern Peru Corp. [PCU], one of the ten largest copper producers worldwide, counts the Toquepala and Cuajone porphyry deposits among its assets. The company's largest shareholders include Grupo Mexico and Phelps Dodge.

Over 370 million pounds of copper and 600,000 ounces of gold were produced from the **Alumbra** mine in 2004 at a cash cost of negative \$0.04 per pound of copper. Located in the northwest of Argentina, the project is owned by **Xstrata** [LSE: XTA] (50%), **Goldcorp** [GG] (37.5%) and **Northern Orion Resources** [TSX: NNO] (12.5%).

Placer Dome [PDG] owns 100% of the **Zaldívar** mine in northern Chile. In 2004, the mine produced 325 million pounds of copper at an average cash of \$0.51 per pound.

The bulk of **Aur Resources'** [TSX: AUR] production comes from two Chilean deposits: **Quebrada Blanca**, in which it has a 76.5% interest, and a 63% stake in the **Andacollo** deposit, which originally was thought to be a porphyry but has since been classified as a manto-type deposit.

Quadra Mining's [TSX: QUA] main asset is the **Robinson** Mine in eastern Nevada, which produced 27.6 million pounds of copper and 14,081 ounces of gold in the first quarter.

Amerigo Resources [TSX: ARG] produces copper and molybdenum from the tailings of Codelco's **El Teniente** mine.

A number of companies are mining porphyry deposits in British Columbia. **Teck Cominco** [TSX: TEK.SV.B] more than doubled its first quarter profit on increased sales of copper and molybdenum from its Highland Valley mine, 60 km southwest of **Kamloops**. **Northgate Minerals** [NXG] is currently mining the **Kemess** deposit in the north-central area of the province and is contemplating [the development of the Kemess North deposit](#). **Taseko Mines** [TGB] recently restarted the high cost [Gibraltar mine](#) in south-central British Columbia, while Imperial Metals [TSX: III] owns the Mount Polley porphyry copper-gold deposit and has a 50% stake in the Huckleberry mine.

Juniors

One of the largest undeveloped porphyry deposits is **Cerro Casale** in northern Chile, with 23 million ounces of gold and 6 billion pounds of copper. The deposit is jointly owned by Placer Dome (51%), **Arizona Star Resources** [TSX-V: AZS] (25%) and **Bema Gold** [BGO] (24%). The Vancouver-based major funded a feasibility study on the project but must make a production decision before the end of 2005 to earn its interest, or else its stake will revert back to Bema. The project has been through some drama because of its high start-up cost - \$1.65 billion .

[Lumina Copper](#) completed its transformation into four separately traded companies this week. One of the spin-offs, **Regalito Copper** [TSX: RLO], contains Lumina's former prize asset – the fully owned Regalito deposit in central Chile, currently estimated to host over 7 billion pounds of copper.

Entrée Gold [TSX-V: ETG] is focused on the **Lookout Hill** prospect, immediately north end of Ivanhoe's Oyu Tolgoi property. Ivanhoe owns 18% of [Entrée](#) and is earning a stake in the Lookout property.

Other juniors looking to develop porphyry copper deposits include **Almaden Minerals** [TSX: AMM], **Corriente Resources** [TSX: CTQ], **Frontera Copper** [TSX: FCC], **Peru Copper** [TSX: PCR], **Ross River Minerals** [TSX-V: RRM], **Cascadero Copper** [TSX-V: CCD], **Climax Mining** [ASE: CMX], **Sur America Gold Corp.** [TSX-V: SUR] and **Monterrico Metals** [AIM: MNA].