PORPHYRY GOLD DEPOSITS: THE RESULT OF HIGH-TEMPERATURE MAGMATIC FLUIDS FLASHING INTO THE GAS + SALT FIELD. John L. Muntean, Placer Dome Exploration, 240 S. Rock Blvd., Suite 117, Reno, Nevada, 89502, JLMuntean@aol.com.

Introduction: The porphyry gold deposits of the Maricunga belt in northern Chile contain the lowest known copper to gold ratios (% Cu/ppm Au = ~0.03) of any porphyry-type deposit. The gold deposits are associated with subvolcanic andesitic to dacitic intrusions emplaced into coeval volcanic rocks. The deposits are generally zoned in space from a deeper porphyry copperlike zone with quartz veinlets (A-veinlets) and potassic alteration to a shallow zone of banded quartz veinlets, which are the cause for the unusually low copper to gold ratios.

Porphyry Copperlike Zone: The deep porphyry copperlike zone is characterized by A-veinlets and pervasive potassic alteration, both restricted to intrusive rocks. A-veinlets, characteristic of porphyry copper deposits throughout the world, contain variable amounts of quartz, magnetite, biotite, and chalcopyrite, have widths <1 cm, and locally have K-feldspar halos. Hypersaline liquid-rich inclusions, coexisting with vapor-rich inclusions in A-veinlets, indicate temperatures as high as nearly 700°C, salinities as high as 84 wt percent NaCl equivalent, and pressures between 200 and 400 bars. Assuming a lithostatic load, depths of 800 to 1600 m are inferred. Zones of abundant A-veinlets contain mostly <1 ppm gold and 0.1 to 0.4% hypogene copper.

Banded Quartz Veinlets: Banded quartz veinlets occur mostly above A-veinlets and cut A-veinlets. They are <2 cm in thickness and lack alteration envelopes. Vein walls are parallel and slightly wavy, and vuggy vein centers are common. Dark gray bands, whose color is due to abundant vapor-rich fluid inclusions and micron-sized grains of magnetite, commonly occur as symmetric pairs near the vein walls. The bands are commonly botyroidal and are continuous through quartz grains, suggesting the quartz recrystallized from a silica gel. Rare liquid-rich fluid inclusions in quartz, coexisting with the vapor-rich inclusions, indicate temperatures ≤350°C, salinities between 17 and 34 wt percent NaCl equivalent, and pressures between 10 and 150 bars. Assuming a hydrostatic load, depths of 200 to 1500 m are inferred. Gold occurs both in the dark bands with magnetite and outside the dark bands with pyrite. Zones of abundant banded quartz veinlets generally contain 0.5 to 2 ppm gold and <0.01% hypogene copper.

Transition from A-veinlets to Banded Quartz Veinlets: A-veinlets formed from a fluid that was in the three-phase field (G+L+S, see figure) consisting of a large volume of low-salinity vapor (~0.01-0.1 wt% NaCl equiv.) and smaller volumes of brine (~60-80wt% NaCl equiv.) and possibly solid salt at 550 to 700°C. The rock would have been ductile and fractured only during periods of high strain rate under largely lithostatic loads. Periodic, upward surges of magma breached the brittle-ductile boundary, resulting in adiabatic decompression to hydrostatic pressures. The liquid-vapor mixture flashed upward into zones of lower pressure, brittle fractures, and the vapor+salt field (G+S, see figure). The pressure drop would have lead to supersaturation with respect to amorphous silica, iron minerals, gold, and halite. As the flashing abated, silica colloids formed a gel charged with vapor bubbles and micron-sized magnetite and gold. As the gel cooled at constant pressure in the vapor+salt field, it would have intersected the liquid saturation curve, condensing water from the vapor bubbles. Given this interpretation, halite was present and its subsequent dissolution would have contributed to the observed wide range of salinities. Also, upon cooling the silica gel recrystallized to quartz.

If sulfur was lost to the vapor phase during flashing, precipitation of iron and iron-copper sulfides would have been inhibited, resulting in deposition of magnetite. Since gold and iron do not need sulfur to precipitate, whereas copper does, this loss of sulfur may be the primary cause of the low copper contents o porphyry gold deposits. Precipitation of late calcite, chlorite, and K-feldspar suggests the presence of near-neutral fluids that may have originated from loss of acid volatiles. Condensation of H_2S may have been important in mobilization and redeposition of gold with pyrite.