

Paper Number: 5292

Links between porphyry and IOCG deposits

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Porphyry Cu±Mo±Au (porphyry) and iron oxide-copper-gold (IOCG) deposits share several key characteristics, most notably their defining enrichments in Cu, Au, and Fe. The amount of Fe in porphyry deposits is commonly overlooked because it is mainly contained as pyrite in phyllic alteration, which is not normally part of the orebody and is not reported in resource figures; lesser magnetite coexists with chalcopyrite in mineralized rocks. In this sense, the predominant form of iron in these deposits is their defining difference, with Fe-sulfides predominating in porphyries, and Fe-oxides (magnetite and hematite) in IOCG deposits. From an ore fluid geochemical perspective, both deposit types require moderately high-temperature, oxidized saline brines for the efficient transport of Cu and Fe (and trace Au). The main difference appears to be that porphyry fluids also carry large amounts of sulfur (dissolved initially as SO₂), resulting in the precipitation of abundant Fe-sulfides and sulfates upon cooling, along with volumetrically minor but economically important Cu-Fe-sulfides. In contrast, IOCG fluids appear to be relatively sulfur poor and precipitate the bulk of the Fe in oxide form (still with volumetrically minor Cu-Fe-sulfides). Because fluids with these basic geochemical characteristics can be generated in a variety of natural settings, ranging from magmatic-hydrothermal to deep sedimentary basins, a wide range of genetic processes have been proposed for IOCG deposits. If iron oxide-apatite deposits are included in the IOCG spectrum, then the range is argued by some to extend to fluxed Fe-oxide melts.

A subset of IOCG deposits is more closely related to intrusive igneous rocks and magmatic-hydrothermal fluids, and we refer to these as magmatic-hydrothermal IOCG deposits (MH-IOCG). These include Proterozoic (1.87 to 1.85 Ga) deposits in the Great Bear Magmatic Zone of northern Canada, and mid-Cretaceous deposits in the Coastal Cordillera of northern Chile. These deposits share many features with porphyry systems, including a spatial and temporal relationship to calc-alkaline intrusions of arc or back-arc affinity, potassic, sodic, and sodic-calcic alteration, and Cu-Au mineralization associated with Fe-oxides.

We have sampled igneous rocks associated with Cretaceous porphyry and MH-IOCG deposit in Chile, and find that the rocks are compositionally almost indistinguishable (typical intermediate calc-alkaline rocks, with similar moderate oxidation states) except for slightly higher Nb contents in the MH-IOCG-related suites. These slightly more “intraplate” characteristics are consistent with the back-arc setting that prevailed briefly in the mid-Cretaceous when these MH-IOCG deposits were formed. In order to test the hypothesis that the porphyry-forming magmas were more S-rich than the MH-IOCG-forming magmas, we analyzed the S content of igneous apatite crystals preserved in phenocrysts, and found that the porphyry-related apatites were distinctly richer in S than the MH-IOCG-related apatites (0.24 ± 0.17 wt.% SO₃ vs. 0.04 ± 0.03 wt.% SO₃). Although the dataset is small, this evidence supports the view that the main difference between porphyry- and MH-IOCG-forming systems is the amount of sulfur present in the magmas from which the ore-forming fluids were exsolved. Porphyry deposits should therefore form in association with oxidized, S-rich arc magmas that characterize Phanerozoic subduction zones,

whereas MH-IOCG deposits should form in association with S-poor magmas that might form more readily in the Precambrian, or back-arc to intra-plate rifting settings in the Phanerozoic.

