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Using igneous petrology to unravel the tectonic triggers for porphyry mineralization

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Recent studies of the magmatic rocks associated with porphyry systems in both continental and island arc environments has shown that the geochemistry of the pre-and syn-mineralization rocks shows systematic variations that can be attributed in some cases to the subduction of aseismic ridges. The role of ridge subduction, either as a source of metals or simply as a cause of flattening and compression, remains to be determined but the fact that ridge subduction is linked to the majority of recent giant porphyry Cu-Mo-Au systems suggests they play a critical role. This talk will examine the evidence for the effects and impact of ridge subduction in Chile and the Philippines.

The Cretaceous to middle Miocene volcanic rocks of Central Chile, host to some of the world's largest Cu-porphyry deposits, are characterized by enriched LREE and negative Nb anomalies, consistent with an arc setting. The geochemical signature of these rocks remains more or less constant until the Late Miocene when a rapid change in the geochemical signature between the end of the eruption of the Farellones Formation and the eruption of the high La/Yb La Copa Rhyolite Complex implies a more abrupt change in the tectonic environment. The subduction of the Juan Fernández Ridge may have been the key geodynamic process responsible for the genesis of the three middle Miocene to lower Pliocene giant porphyry copper deposits in central Chile, possibly by promoting crustal-scale faulting and even acting as a source of metals.

The Baguio district of the Philippines is one of the world's premier mineral provinces, containing >35 million ounces (Moz) of gold and 2.7 million metric tons (Mt) of copper in epithermal, porphyry, and skarn deposits that formed in the last 3.5 m.y. The geochemical and isotopic characteristics of the Pliocene and Pleistocene magmatic rocks of the Baguio district are characteristic of primitive mantle-derived melts that underwent minimal crustal contamination prior to emplacement. In contrast, the intermediate to felsic suite has been contaminated by young arc crust, suggesting ponding and fractionation within shallow-crustal magma chambers. The early mafic suite is broadly coeval with the onset of subduction of the Scarborough Ridge and slab flattening. The young aseismic ridge would have been more susceptible to melting than the downgoing plate and those melts may explain the isotopic recharge of the Pliocene subarc mantle as well as the generation of the primitive melts and adakitic rocks found within the Baguio district. The interaction between primitive mafic melts and the more felsic calc-alkaline rocks has generated fertile melts that were highly productive for porphyry copper and epithermal gold mineralization. Evidence for this interaction is preserved in hornblendes from the Black Mountain Southeast Cu-Au-(Mo) porphyry deposit. The hornblendes can be divided into two groups: one formed at depth in a mafic magma and the other at shallower levels in a felsic magma. The presence of both groups within a single sample suggests mixing of mafic and felsic magma, consistent with the recharge indicated by the district scale whole rock geochemistry. Porphyry mineralization in the Black Mountain area is interpreted to have formed as a result of underplating of a felsic magma chamber by a mafic magma that formed as a result of mantle recharge related to the subduction of the aseismic Scarborough Ridge.