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What Caused the Formation of the Giant Bingham Canyon Porphyry Cu-Mo-Au Deposit? Insights from Melt Inclusions and Magmatic Sulfides

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Porphyry Cu deposits are commonly thought to have formed by magmas that were unusually rich in metal and/or sulfur. In this study, we test this assumption by reconstructing the metal and sulfur content of an ore-related latite magma at Bingham Canyon and comparing it with that of intermediate magmas in several other arc magma systems. The ore-related latite magma at Bingham Canyon records strong evidence for magma mixing and has a major to trace element composition that can successfully be modeled by a mixture of ~40 wt % mafic magma that was similar to the most mafic rock found at Bingham Canyon (a melanephelinite containing 45 wt % SiO_2) and ~60 wt % felsic magma of rhyolitic composition. Based on the modal abundance of sulfides in this rock and LA-ICP-MS analyses of unaltered sulfide inclusions preserved within hornblende and plagioclase phenocrysts, the latite magma contained 50 to 90 ppm Cu, 0.8 to 2.0 ppb Au, 2 to 3 ppm Mo, and >= 0.12 to 0.14 wt % S. The available data suggest that the bulk of the sulfur, copper, and Au in the latite magma were derived from the mafic end-member. Therefore, the amount of sulfur and copper present in the mixed magma can also be estimated from their abundance in mafic, sulfide-undersaturated melt inclusions and the amount of mafic magma involved in the magma mixing.

Applying the latter approach to two other porphyry Cu-mineralized magma systems (Santa Rita, USA, and Bajo de la Alumbrera, Argentina) and five to 12 modern arc magma systems suggests that the ore-forming magmas in mineralized systems were not unusually Cu rich. The mafic end-member magmas at Bingham Canyon and Santa Rita were not particularly rich in sulfur and chlorine, either, and there is no indication that they were more hydrous than basalts in barren arc magma systems. If these trends prove to be true, then the most distinctive feature of fertile magma systems may simply be the development of large, long-lived, upper crustal magma chambers and associated vent structures that enable focused fluid flow.