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Porphyry Deposits May Not Require a Unique Melt

Ijaz Ahmad, Pedro J. Jugo, Jeremy P. Richards
Laurentian University, Sudbury, ON, Canada

Porphyry deposits are a major source of Cu, Mo, and Au and are associated with felsic to intermediate intrusions emplaced in the upper crust (2–5 km) during arc magmatism. Sulfide saturation in the lower crust is thought to play a vital role in the fertility of such magmas by scavenging chalcophile elements (Cu, Au, PGEs) due to their higher partitioning into sulfide melt, resulting in depletion of these elements in the derivative melts that ascends to the upper crust. We test this hypothesis in the Kohistan island arc, northern Pakistan, which exposes two distinct lower crustal sections in the south (Jijal and Chilas) and one mid to upper crustal section in the north (Kohistan batholith). Whole-rock geochemistry data from the lower crustal sections show depletion in Os and Ir compared to the mantle, suggesting that these elements were retained by residual monosulfide solid solution in the mantle source. However, Pt, Pd, Au, and Cu are undepleted relative to the mantle, suggesting extraction from the mantle source. In contrast, the mid to upper crustal section is diminished in Pt, Pd, Au, whereas Cu maintains mantle-like concentration in these rocks. We interpret that this is caused by the segregation of sulfides in the lower crust, as in situ LA-ICP-MS analysis of sulfides shows ppm level concentration of these elements. Modeling the effect of sulfide on the metal budget of the Kohistan magmas indicates that segregation of small amounts (< 0.17 wt %) of sulfides would not significantly affect the Cu budget of the melt that could rise to the upper crust. Such melts, although depeleted in PGEs, would contain sufficient amounts of Cu to form porphyry Cu deposits. Thus, systems like the Kohistan batholith could potentially generate a deposit of 4–5 Mt Cu with an extraction efficiency of 70 to 100%, confirming that these deposits may not require a unique (metal-rich) melt.