Contrasting Tectonomagmatic Conditions for Porphyry Cu and Iron Oxide-Apatite Deposits in Phanerozoic Arcs

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Porphyry Cu ± Mo ± Au and iron oxide (± apatite, IOA; ± copper-gold, IOCG) deposits commonly occur in close spatial and temporal proximity in Phanerozoic arc-related settings. However, the evolution of these deposit types in an evolving arc setting remains poorly understood. Here, we systematically evaluated the P-T-fO_2 conditions and S-Cl contents for the dioritic to granodioritic source magmas for representative magmatic-hydrothermal porphyry-skarn Cu ± Au (150–135 Ma) and IOA (~130 Ma) deposits that formed under transpressional and transtensional settings in the Middle-Lower Yangtze River Metallogenic Belt, China. Our estimates show that, compared to IOA deposits, the porphyry-skarn-related magmas were relatively felsic, cooler, more hydrous, and emplaced relatively deeper (264 ± 23 vs. 143 ± 17 MPa for IOA-related magmas; 2SE). Apatite data reveal that the porphyry-related and IOA-related magmas had comparable pre-degassed S concentrations (~0.13 ± 0.06 vs. ~0.16 ± 0.09 wt. % on average), but that IOA-related magmas had higher pre-degassed Cl/H_2O ratios (~0.10–0.15 vs. 0.02–0.08 wt. % for porphyry-related magmas) that decreased by a factor of two after magma degassing. Magmatic fO_2 estimated using zircon and amphibole, reported in log units relative to fayalite-magnetite-quartz (FMQ) redox buffer, gradually increased during cooling of the porphyry-skarn-related magmas (ΔFMQ +0.7 to +2.5) at 950° to 800°C and decreased to ΔFMQ +1 at 700°C. In contrast, the magmatic fO_2 for the IOA-related magmas varied significantly from ΔFMQ -1.5 to ΔFMQ +2.5 but generally showed an increasing trend with cooling from 970° to 700°C. We propose that the porphyry-skarn Cu deposits in the MLYRMB formed in a compressional setting in response to normal plate subduction that favors storage and evolution of S-rich hydrous ore-forming magmas at variable crustal levels, whereas the back-arc extensional setting that formed because of slab rollback led to rapid degassing of the Cl-rich magmas.