Origin of giant post-collisional porphyry Cu metallogenic belt in southern Tibet: constrains from magmatic H_2O, fO_2, and S

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Porphyry copper deposits (PCDs) are generally associated with oxidized, and H_2O-S-rich magmas, typical features of magmatic arcs (Richards, 2003; Sillitoe, 2010). In island arcs and continental arcs, where porphyry deposits form, it is generally thought that oxidized, sulphur-rich fluids released from subducting slabs migrate into the asthenospheric mantle wedge, where they cause partial melting and mobilization of metals (Richards, 2003), and ultimately transfer these metals into the crust. Recently, large porphyry copper deposits (PCDs) have been found in association with post-collisional (Miocene; 22–12 Ma), high-Sr/Y granitoid plutons emplaced in the eastern section of the Paleocene-Eocene Gangdese magmatic arc in the Himalayan-Tibetan orogenic belt (Hou et al., 2004, 2015; Yang et al., 2009; Wang et al., 2018). These discoveries raise questions about the nature of magmatic and metallogenic processes during continental collision.

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We review the literature and compile available data on whole rock and isotope geochemistry for Cenozoic igneous rocks from Tibet, with new zircon Ce^{4+}/Ce^{3+} and Ti-in-zircon thermometry data to better understand variations in oxidation state and thermal evolution of these suites, which are key controls on Cu mineralization. Porphyry copper mineralization is associated with a moderately oxidized ($\Delta FMQ = +0.8$ to $+2.9$), water-rich (≥4.5 wt.%) high-Sr/Y granitoid suite with minor occurrences of transitional (hybrid) monzonitic and trachytic rocks (Wang et al., 2014ab). The Miocene high-Sr/Y granitoids have many compositional and isotopic similarities to the Paleocene-Eocene Gangdese arc rocks, and are interpreted to have been derived by melting of the hydrated arc root, with minor mantle input (Wang et al., 2015, 2018).

Although partial melting of subduction-modified lower crust has been proposed to generate such magmas, the main debate arises from the discussion that whether the lower crust can provide enough S for giant porphyry deposit formation. In addition, the porphyry system is common with several pulses of magmatism coeval with mineralization. It is unclear that why one pulse of magma is ore causative but the rest. Qulong deposit is the largest porphyry Cu-Mo deposit in China and located in the Tibetan-Himalayan collisional zone. The mineralization is related to a protracted magmatism with several pulses of intrusions through an interval of ~1.5 Ma (Yang et al., 2009; Li et al., 2017).

We here report the S, F, Cl contents and *in situ* SIMS S-O isotopic compositions of magmatic apatites from all pulses of Qulong intrusions and adjacent mantle-derived trachyandesite. The apatite from ore-forming intrusion, P-porphyry, is unique with the highest F, Cl and MnO contents, lowest $\delta^{18}O$ ratios, largest S isotopic variations among Qulong intrusions. The high-S band with high $\delta^{34}S$ ratios is found in apatite grains from P-porphyry, and such high $\delta^{34}S$ ratios are similar to apatites from mantle-derived trachyandesite. These results support the idea of adding a shot of mantle-derived sulfur to the system to make it fertile, and this most likely comes from a pulse of more mafic magma. This might explain the origin of giant porphyry deposits in collisional zone.

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