Metal cycling at subduction zones - function of magma type, volatile load, redox, pathways, and tectonics

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Characteristics of very large “porphyry copper” deposits include: 1. parental magmas are predominantly oxidized, sulfate-rich “calc-alkaline” (plus some “high-K calc-alkaline”) types; 2. elevated abundances of Cu and Au in parental magmas; 3. compressive tectonic regimes required in thickened continental crust overlying temporally and spatially restricted morphologies of subducted oceanic plates; 4. complex sequences of “gas” loss of alkalis and metals from cupolas on the tops of subjacent “plutons” and subsequent brine+vapour interactions with surrounding crust. More generally, metal cycling at subduction zones is a function of these parameters. The compositional diversity of magmas in arcs is large; Schmidt and Jagoutz (2017) identify six principal types concluding that mantle wedge heterogeneity, proportions and types of subducted slab additions, and reactive fractionation in the base of the overlying plate are controlling factors for this diversity. Slab-derived melt additions are common in continental arcs but rare in intra-oceanic systems. The highest magmatic fluxes into the crust are developed in low-Fe-K (tholeiite)-dominated intra-oceanic arcs. Many arc magmas are mixtures of diverse primitive magmas. The notion that boninite types are restricted to subduction inception is untrue; these types are currently being erupted in the Tonga arc front and reararc, and form one component of the predominant low-Fe-K tholeiites of the arc. Redox state and intrinsic chalcophile and precious metal abundances of primitive (aka parental) magmas in arcs are variable. At crustal (volcanic and plutonic) levels, arc magmas are more oxidized than those at mid-ocean ridges. But where this redox state is established is not settled. Concurrent enrichment with and oxidation of the mantle wedge by sulfate-rich, slab-derived fluids has been advocated in the past few years but others have concluded identical values of the ratios of redox-sensitive transition metal abundances in primitive MORB and arc magmas require oxidation of the latter during the ascent from mantle through the overlying crust. A number of studies combining stable isotope (e.g., Fe) and detailed studies of mantle wedge-derived peridotites suggest the processes are still more complex, leading to a redox spectrum as a function of mantle wedge composition, style of melting, ascent history, and sulfate-sulfide stability.