Cumulate causes for the low contents of chalcophile elements in the continental crust

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In addition to the formation of economically important ore deposits, chalcophile and siderophile element (CSE) systematics of magmatic rocks can be used to place constraints on a range of processes such as the evolution of the Earth's mantle and crust, delamination and subduction. Many of these constraints rely on knowledge of the minerals partitioning the CSE and comparisons between the compositions of subduction-zone magmas and mid-ocean ridge basalts (MORB). However, because the contents of many CSE are hard to analyse accurately in rocks and minerals, compositions and ratios used for comparative geochemistry are often based on scant datasets and/or relatively untested proxies. Consequently, there remains a lack of consensus regarding which minerals partition the CSE and, for example, which processes cause the continental crust to become enriched in some CSE and depleted in others compared to the oceanic crust.

Using a broad range of CSE, I show that average-MORB values and certain ratios used for comparative geochemistry can be misleading, because they do not sufficiently separate between mantle and crustal processes. I show that mantle-derived melts contributing to oceanic and continental crust formation rarely avoid sulfide-saturation and, on average, subduction-zone magmas fractionate sulfide at the base of the continental crust prior to ascent. Furthermore, I show that silicate not sulfide minerals dominate the bulk partitioning of many of the CSE during magmatic processes.

Differentiation of mantle-derived melts causes sulfide- and silicate-bearing cumulates constituting the lower oceanic and continental crust to become enriched in some CSE (e.g., Cu, Ag and Au) compared to the upper crust. This 'storage' predisposes the cumulate-hosted CSE to be recycled back into the mantle during subduction and delamination, resulting in their low contents in the bulk continental crust. By contrast, differentiation causes the upper oceanic and continental crust to become enriched in 'incompatible' CSE (e.g., As, Tl, Sb) compared to the lower oceanic and continental crust. Consequently, incompatible CSE are predisposed to become enriched in subduction-zone magmas that contribute to continental crust formation and are less susceptible to removal from the continental crust via delamination.