

# Disequilibrium between sulfides in mantle rocks: Implications for chalcophile element cycling

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It is now well established that sulfide assemblages in mantle peridotites were often not fully equilibrated during melt infiltration processes at high temperatures. Platinum group elements (PGE) provide critical evidence which includes: (1) grain- to centimeter-scale heterogeneities in initial  $^{187}\text{Os}/^{188}\text{Os}$  (in cases where the time of melt infiltration is well constrained), (2) differences in chalcophile element abundances of sulfides on grain boundaries and sulfide inclusions in silicates, (3) variations of the PGE in many peridotites that are controlled by mixing of different populations of sulfides, rather than sulfide-silicate equilibrium partitioning. These constraints imply that abundances of incompatible chalcophile elements such as Au, Re, Cu, Ag, S, Se and Te in bulk rocks also reflect disequilibrium. Detailed studies indicate that the budgets of these elements in many fertile mantle rocks are controlled by the segregation of sulfide melt enriched in incompatible chalcophile elements from infiltrating magma. Thus, the composition of the magma determines the composition of incompatible chalcophile elements in these mantle rocks. Fractional melting signatures of lithophile elements in the same rocks suggest that melts were extracted nearly simultaneously with melt infiltration. If melt infiltration and concomitant sulfide segregation control magma and peridotite compositions at depth, what partition process controls the chalcophile element patterns of infiltrating magmas and primitive basalts? The answer may lie in the combined enrichment of incompatible chalcophile elements, Pd and Pt in sulfide melt segregated from infiltrating mantle magmas. This composition represents a signature of relatively high degrees of melting, commonly believed to occur at the top of melting columns, e.g. during formation of oceanic crust. At high degrees of melting, most sulfides should have dissolved in the magma and incompatible chalcophiles + Pd are transferred quantitatively into silicate melt. In contrast, lower abundances of Pt, Rh, Ru, Ir and Os in such magmas likely reflect retention of Pt-Ir and Os-Ir-Ru-rich alloys in the residues. During melting of recycled oceanic crust in the upper mantle, complete dissolution of sulfide melt may transfer these sulfide compositions into primitive magmas that infiltrate overlying mantle rock.