



Sulphides in the sub-continental lithospheric mantle (SCLM): unravelling the effects of melt depletion and metasomatism using Re-Os isotopes

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It has long been known that the Re-Os budget of mantle rocks is almost entirely controlled by the presence of volumetrically insignificant sulphide grains (1,3,5). Recent studies of oceanic lithospheric mantle (2) and sub-continental lithospheric mantle (SCLM) (3) have revealed the presence of at least two different populations of sulphide grains based upon their major element and Os concentration (2) and their $^{187}\text{Os}/^{188}\text{Os}$ isotopic ratio (3). These two populations have been shown to correspond to texturally distinct sulphides that occur either as inclusions trapped in the primary silicate phases or else as interstitial grains, often in textural equilibrium with the primary silicates. This study presents Re – Os elemental and isotopic data for sulphides separated from spinel lherzolite xenoliths from Kilbourne Hole, New Mexico, USA. The xenoliths selected are considered to be representative of SCLM that has experienced varying degrees of melt extraction (1.13 – 4.14 wt% Al_2O_3). Whole rock $^{187}\text{Os}/^{188}\text{Os}$ ranges from 0.11592 to 0.13247, and also reflects the range of melt depletion experienced. Two distinct populations of sulphide grains are present in these xenoliths. The first type of sulphide, is usually hosted in the silicate phases, has high Ni/Cu ratios (13.3 – 118), high Os concentrations (≤ 37 ppm) and unradiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios, similar to the whole rock values or lower. These are analogous to the pentlandite - rich samples of (2) and the silicate enclosed sulphides of (3). The second type of sulphide, are interstitial, have low Ni/Cu ratios (0.12 – 22.18), generally low Os concentrations (0.01 – 1.17 ppm) and radiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios (usually higher than the whole rock values). These are analogous to chalcopyrite – rich samples of (2) and interstitial samples of (3). The similarity in the distribution of Re-Os between sulphides in

both sub-continental and sub-oceanic mantle implies that the controls on Re-Os isotopic systematics, i.e. melt extraction and subsequent metasomatism, may operate in similar ways in both lithospheric settings.

In most cases, the Os budget of each xenolith is dominated by the relatively unradiogenic sulphide that is enclosed in silicate. These sulphides have the highest Os concentration and $^{187}\text{Os}/^{188}\text{Os}$ isotopic ratios similar to those of the whole rock. Nevertheless, the whole rock isotopic ratio is sometimes perturbed by the varying proportions of silicate minerals and sulphide residual distributed along grain boundaries. The grain boundary sulphide is in both textural and chemical equilibrium with coexisting silicate phases, and would appear to be residual after melting and / or subsequent metasomatism and will therefore vary according to the degree recrystallisation accompanying melt depletion and any metasomatic addition of sulphide.

Silicate and oxide phases separated from Kilbourne Hole xenoliths typically have low Os abundances: olivine = 4 – 104 ppt, orthopyroxene = 8 – 127 ppt, clinopyroxene = 38 – 166 ppt, spinel = 428 – 1225 ppt (4) (5) providing a minor, yet significant contribution to the Os budget of mantle peridotite. A simple mass balance calculation shows that the silicate and oxide contribution to the whole rock Os budget is less than 5%. Only c. 0.075% of the typical included sulphide and a similar modal % of the interstitial sulphide could account for the remaining 95 % of the Os in the whole-rock and control the Os isotope composition. These estimates of sulphide abundances are consistent with observed sulphide abundances in Kilbourne Hole xenoliths (6). These results illustrate the precise way in which sulphide controls the Os budget of mantle rocks. They also show that while metasomatism may well affect the Os systematics of interstitial sulphide (in the same way that rare earth elements are affected in the coexisting silicates) the Os budget, at least for these samples, is not significantly affected and reflects primary distribution and depletion accompanying melting.

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