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In situ measurements of lead and other trace elements in abyssal peridotite sulfides

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Abstract

In the mantle, base metal sulfides have been proposed as the main host for many chalcophile and siderophile elements. This includes elements such as Pb, Se, and Te, which are often used as tracers of processes ranging from planetary accretion to mantle melting. We present in situ measurements of these elements, along with As, Sb, Ag, Au, and Cl, in abyssal peridotite sulfides to provide constraints on the storage of these elements in the mantle. A total of 152 sulfides from 11 peridotites and 1 pyroxenite from the Gakkel and Southwest Indian ridges were analyzed. The sulfides are pentlandites, some of which contain either discrete chalcopyrite domains or Cu-rich intergrowths. Trace-element concentrations in 108 unaltered sulfides range from 2 to 36 ppm Pb, 45 to 250 ppm Se, <4 to 360 ppm Te, <1.5 to 1900 ppm As, 2 to 420 ppm Sb, 2 to 340 ppm Ag, 2 to 770 ppb Au, and 0.2 to 1000 ppm Cl. Tellurium abundances are highly variable within sulfides, which is likely due to the presence of telluride micro- or nano-phases. Based on morphology, composition, and the absence of monosulfide solid solution, the sulfides are interpreted to have formed by fractional crystallization from sulfide melt during conductive cooling of the mantle beneath the ridge axis. The average sulfide Pb concentration of 4 ppm can be reproduced by >90% fractional crystallization from a sulfide melt. The remaining sulfide melt, which is modeled to contain 800 ppm Pb, will dissolve into silicate melt as it rises through the mantle due to the increasing solubility of sulfur in silicate melt as pressure decreases. However, the amount of sulfide melt that remains after fractional crystallization is too low (mode of <0.005%) to contribute a significant amount of Pb to mid-ocean ridge basalts. We conclude that sulfides are not the main host for mantle Pb, even prior to the onset of any melting, and that the majority of mantle Pb is stored in silicate phases.

Keywords: Mantle, Pb, SIMS, sulfide, peridotite; Planetary Processes as Revealed by Sulfides and Chalcophile Elements