

Abyssal peridotite constraints on lead in the Earth's mantle

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The mineralogical hosts of lead in the mantle are poorly constrained, despite the use of Pb isotopes to explore the long-term evolution of the Earth. To address this, we measured the Pb content of bulk rock peridotites and their constituent minerals. We focused on abyssal peridotites from the Gakkel and Southwest Indian Ridges, including a subset of unusually fresh Gakkel peridotites.

Our laser ablation ICPMS datasets for olivine and pyroxenes indicate that Pb abundances are <10 ppb in these phases. Using mineral modes, we calculate bulk rock concentrations of <15 ppb Pb, which increases to <17 ppb Pb if we include the contribution from trace sulfides. These results agree with our measurement of <17 ppb Pb in bulk rock samples measured by isotope-dilution TIMS. Hence, the majority of Pb in our peridotites is stored in silicate phases. In addition, our values for bulk Pb concentrations are lower than many literature values, which extend to >100 ppb Pb due to the influence of melt-rock and fluid-rock interaction on bulk rock abundances.

To evaluate the behavior of Pb during mantle melting, we used a nonmodal fractional melting model to estimate that our samples underwent 4 to >18% melting based on rare earth element abundances. Using this extent of melting and a peridotite/melt Pb partition coefficient of 0.01, our samples should contain <1 ppb Pb after 4% melt removal, much lower than our measured concentrations. However, co-located basalts indicate that Pb behaves similarly to Nd during melting, with a peridotite/melt Pb partition coefficient of 0.026. Combined with location-specific basalt Pb/Nd ratios, we calculate that the Gakkel source mantle has 32 ppb Pb and SWIR has 52 ppb Pb prior. Using these updated values, our samples are predicted to have 0.03-12 ppb Pb after 4-18% melt removal. These ranges agree with our peridotite bulk rock dataset, suggesting that Pb abundances in peridotites can be reconciled with associated basalts if the Pb content of the mantle source is allowed to vary.