

The distribution of lead and thallium in mantle rocks: Insights from the Balmuccia peridotite massif (Italian Alps)

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ABSTRACT

Sulfides in mantle rocks sometimes have unradiogenic Pb isotopic compositions and, assuming specific conditions, may represent a low U/Pb reservoir that might balance the radiogenic Pb isotope reservoirs of the silicate Earth. A critical requirement to test this hypothesis is knowledge of typical Pb contents in sulfides from different types of mantle rocks and estimates of their contribution to the Pb budget of the mantle rocks. However, data on the distribution of Pb between mantle minerals in mantle rocks from different geologic settings are scarce. In this study, new Pb and Tl concentration data from well-characterized unserpentinized spinel-facies peridotites and pyroxenites from the Balmuccia mantle tectonite (Ivrea-Verbano Zone, Italian Alps) are presented as an example to better understand the Pb distribution in minerals and rocks of the upper mantle.

Most peridotites display variable bulk-rock Pb contents (13–97 ng/g), which tend to be lower than Pb contents in the websterites (60–254 ng/g) and clinopyroxenites (174–657 ng/g). The pyroxenites show broadly positive correlations of Pb with Al₂O₃, Ce, and also S contents. In situ laser ablation-ICP-MS data indicate low Pb contents in olivine, orthopyroxene, and spinel (mostly below the detection limits of 50 ng/g); whereas Pb contents are higher in clinopyroxene (from <50 to 920 ng/g) and in sulfides (typically a few micrograms per gram and sometimes higher in chalcopyrites). Mass-balance calculations indicate that silicates predominantly control Pb contents in bulk rocks (>70–80% of the Pb), with a minor role for sulfides (mostly <20%). This result from Phanerozoic subcontinental lithosphere mantle rocks is consistent with data on abyssal peridotites. As in some previous studies, bulk-rock Pb contents calculated from constituent phases of peridotites are often lower than the measured values. This imbalance mainly reflects trapped fluid inclusions in silicate minerals and, perhaps also fine-grained crystallization products of trapped melt along grain boundaries. Bulk-rock Tl contents in peridotites (0.05–3.5 ng/g) are lower than in pyroxenites (0.66–7.9 ng/g) and display no correlations with Al₂O₃ and S contents. The bulk-rock data probably reflect the highly heterogeneous distribution of Tl in sulfides (<0.01–110 µg/g), and, as for Pb, the effect of trapped fluid inclusion. Because the Pb budget in mantle rocks is mainly controlled by silicates, mantle sulfides with unradiogenic Pb isotopic compositions likely cannot balance radiogenic Pb isotopic compositions of oceanic basalts.

Keywords: Peridotite, pyroxenite, sulfide, lead, thallium; Planetary Processes as Revealed by Sulfides and Chalcophile Elements