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Os Isotopic Composition and Abundance of Highly Siderophile Elements in Mantle Peridotites and Dikes from the Ivrea Zone in Italy

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The Ivrea-Verbano Zone (IVZ) is a slice of lower crust which has been intruded by mantel magmas about 270Ma. This age also represents a minimum age for bodies of mantle peridotite emplaced into the IVZ, such as the Balmuccia and Baldissero massifs (Mayer et al., 2000). These bodies consist mainly of spinel-lherzolite, harzburgite and dunite, and are cut by Cr-diopside and Al-Augite dikes. The systematic variations of major elements in the mantle peridotites, such as the decrease of Al_2O_3, CaO or TiO_2 contents with increasing MgO content, have been interpreted to reflect the extraction of mantle magmas formed by increasing degrees of partial melting. However, Obermiller (1994) observed a large variation of the Nd-isotope composition of clinopyroxene separates from the mantel peridotites and in the dikes, as $\varepsilon_{Nd(T=270)}$ ranges from 3 to 11. In addition, REE patterns of clinopyroxene in peridotites and dikes range from LREE depleted to moderately enriched (Rivalenti et al., 1995). These observations have been interpreted to reflect the interaction of the dike melts with mantle peridotite (Rivalenti et al., 1995; Obermiller, 1994).

The concentrations of the highly siderophile elements (HSE) Ir, Os, Ru, Pt, Pd and Re in the least Al_2O_3-deleted peridotites overlap with estimates of the primitive mantle composition, as chondrite-normalized abundances range from 0.01 to 0.008 with Pt/Ir_N of 0.8 to 1.0. The concentrations of all HSE in spinel-lherzolites with less than 2wt% Al_2O_3 are lower (0.0015-0.004 times chondritic) and Ir, Ru, Os become fractionated from Pt, Pd and Re (Pt/Ir_N of 0.3 to 0.7). Dunites have the lowest concentrations (<0.0015 times chondritic) and the most fractionated chondrite-normalized HSE-pattern ($Pt/Ir_N<0.3$). A similar distribution of the HSE in the Ivrea peridotites has been observed by Garuti et al. (1984). The least-depleted peridotites have $^{187}Os/^{188}Os$ (T=270Ma) of 0.121 to 0.124 which is slightly below the chondritic value of 0.125 at this time. Re-depletion model ages range from 200 to 600Ma. These peridotites have $\varepsilon_{Nd(T=270)}$ of 8-11 and depleted mantle model ages range from 280 to 550Ma (Obermiller, 1994). Therefore, their Os and Nd isotopic compositions are typical for depleted upper mantle. The Al_2O_3-depleted lherzolites and the dunites have radiogenic Os isotopic compositions ($^{187}Os/^{188}Os$: 0.127-0.130) and lower $\varepsilon_{Nd(T=270)}$ of 3-8. Thus, with increasing depletion of Al_2O_3 and HSE, the peridotites become deleted in Pt, Pt, and Re relative to Ir, Os and Ru and indicate the involvement of a component with a long-term enrichment of Re and Nd relative to the depleted mantle.

The Cr-diopside and Al-Augite dikes have very low concentrations of HSE (<0.0025 times chondrites), but are enriched in Pt, Pd, and Re relative to Ir, Os and Ru (Pt/Ir_N = 2-50). Thus, their chondrite-normalized HSE pattern is typical for mantle-derived melts and complementary to that of the peridotites. Their Os isotope compositions are variable, but radiogenic with $\gamma_{Os(T=270)}$ ranging from 10 to 95. Similarly, $\varepsilon_{Nd(T=270)}$ ranges from 2.2 to 6.3 (Obermiller, 1994).

These observations can be explained by the mobilization and exchange of HSE during the interaction of a radiogenic mantle melt with an upper mantle peridotite. As the melt continuously percolates through the peridotite, HSE, particularly Pd, Pt and Re, become dissolved in the melt, leaving behind HSE-depleted peridotites. In the Ivrea Zone, these metals are probably concentrated in sulfide-rich pyroxenites (Garuti et al. 1984). During the interaction radiogenic Os from the melt equilibrated with mantle Os, which explains the radiogenic isotopic composition of the Al-poor peridotites and dunites and the highly variable Os isotope composition of the dikes. Thus, the depletion of Pd and Pt relative to Ir, Os and Ru observed in refractory orogenic and abyssal peridotites does not necessarily imply a large degree of partial melting, but can also be the result of melt percolation processes.

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