

PGE and Os and Nd isotopes from the Oman Ophiolite: Implications for MANTLE Heterogeneities

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This study investigates mantle heterogeneities introduced by melt percolation and refertilisation processes via silicate and sulphide melts. Os isotope ratios of peridotites from the Oman ophiolite cover a wide range from highly unradiogenic to radiogenic values. The most unradiogenic harzburgites ($^{187}\text{Os}/^{188}\text{Os}_{(t=90\text{Ma})} = 0.1149$ and 0.1169) yield Re depletion ages of ~ 2 Ga. They represent the most depleted members of oceanic lithosphere (e.g. $\text{Yb}_N(\text{cpx}) \sim 1.1$; $\text{Ti}_N(\text{cpx}) \sim 0.3$), (Pd/Ir_N ratios of < 1). Rare sulphides (Pn and minor Cp) with grain sizes ranging from 10-60 μm are associated with opx or olivines. The remaining residual harzburgites ($^{187}\text{Os}/^{188}\text{Os}_{(t=90\text{Ma})} \sim 0.124$) have broadly chondritic relative PGE abundances with the exception of high Pd/Ir_N and positive Pd anomalies. These samples have sulphides which occur typically as interstitial, subhedral or anhedral grains with curvilinear boundaries. The grain sizes frequently range up to 400 μm and the sulphides are closely associated with spinel and/or cpx. A second type of samples belongs to a non-residual group comprising cpx- and plag enriched peridotites, dunites and pyroxenitic dikes. These samples are characterized by melt-type low PGE abundances, high Pd/Ir_N ratios and high Os isotope ratios ($^{187}\text{Os}/^{188}\text{Os}_{(t=90\text{Ma})} = 0.1367$ to 0.1675). The positive covariations of the Os isotopes with Pd/Ir ratios and lithophile elements indicate interaction with percolating melts. The primary sulphide assemblage is composed of massive pyrrhotite + Cp + Pn. Large sulfide grains (up to 700 μm) are attached to coarse grained, subhedral cpx and/or spinel. It is suggested that the Os isotope heterogeneity is largely due the mobility of sulphide melts during partial melting and melt percolation. High degrees of melting may leave sulphide inclusions in silicate minerals that preserve an ancient melt depletion event. Such ancient component may be frequently masked by relative radiogenic sulphides precipitated from percolating melts. The Oman pyroxenites originate from a high-Re/Os reservoir. Their Nd isotopic composition points to a long-term source depletion of Nd ($^{143}\text{Nd}/^{144}\text{Nd}_{(t=90\text{Ma})} = 0.513299$), suggesting a depleted upper mantle origin.

Geochemical processes including sorption and incorporation of heavy metals and arsenic by scoria and steel slag

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Kinetic and equilibrium sorption experiments on scoria from volcanic cones of Jeju Island and steel slag (basic oxygen furnace slag: BOFS) from the Pohang Iron & Steel Works, Korea, were performed to investigate the geochemical processes affecting the removal of heavy metals (Pb(II), Cu(II), Zn(II), Cd(II)) and arsenic (As(III)) from aqueous solutions. The scoria is vesicular and consists of forsterite, pyroxene, labradorite, hematite and traces of clay minerals. The BOFS is massive and comprises free lime, calcium silicates, calcium iron aluminum oxide, and magnetite.

Batch-type kinetic sorption tests showed that removal efficiencies of heavy metals (except Pb(II)) and arsenic were generally slightly higher for BOFS than scoria. However, hydration of the slag material resulted in a relatively high pH (>11) in solutions. The observed changes of ionic concentrations during sorption suggested that geochemical removal of heavy metals was mainly caused by cation exchange for scoria and the precipitation as metal hydroxides for BOFS. In contrast, arsenic removal appeared to result from the physical adsorption onto hematite (for scoria) and calcium-arsenite precipitation (for BOFS). The results from sorption kinetic experiments fitted better to a pseudo-second-order sorption model than to a first-order model (i.e., Lagergren equation). The equilibrium sorption tests showed that at alkaline pH conditions the removal of heavy metals by scoria was enhanced by precipitation as hydroxides due to an increase in pH. In a multi-component solution containing heavy metals and arsenic, the arsenic removal efficiency increased with increasing pH, which can be attributed to the coprecipitation of As with metal hydroxides. The equilibrium sorption of heavy metals onto scoria was consistent with the Langmuir isotherm, while that of arsenic followed the Freundlich isotherm.