186Os-187Os systematics in plume-related lavas: core-mantle interaction or crust-mantle interaction?

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There is growing evidence from major, trace elements and isotopic systematics that pyroxenites are a significant constituant of oceanic basalt sources. A composite pyroxenite-peridotite mantle source has been suggested as an alternative explanation for the coupled ^{186}Os-^{187}Os isotopic anomalies found in plume-related lavas and originally attributed to core-mantle interaction. To test this hypothesis, we investigated pyroxenites from the Beni Bousera (BB) orogenic massif, together with base-metal sulfides (BMS) from BB pyroxenites and eclogite xenoliths to constrain their highly siderophile elements (HSE) and ^{187}Os-^{186}Os systematics.

The BB pyroxenites show pronounced but variable enrichment of Pt and Re over Os. Calculated ^{187}Os/^{188}Os$_{\mathrm{C}}$ ratios are systematically radiogenic. ^{186}Os/^{188}Os$_{\mathrm{C}}$ ratios range from chondritic to highly radiogenic values (0.1198401-0.1198934). Of the two ^{186}Os/^{188}Os$_{\mathrm{M}}$ measurements performed, one pyroxenite has a radiogenic ratio(0.1198571$\pm$60) within error of the predicted one (0.1198642) but the other sample has a non-radiogenic ratio(01198262$\pm$11),far lower than the predicted one (0.1198401), indicating some recent change in parent-daughter ratios.A simple 2-component bulk mixing model calculated between a present-day mantle peridotite and the two pyroxenites with the highest ^{186}Os/^{188}Os$_{\mathrm{C}}$, indicates that a partial melt containing 50-90% of pyroxenite-derived melt would have combined ^{187}Os/^{188}Os and ^{186}Os/^{188}Os ratios similar to the radiogenic plume-related lavas.

However, this mixing model does not consider that HSE are hosted in the mantle by highly fusible and highly mobile BMS that are able to generate isotopic heterogeneities at the micrometric scale. Re/Os and Pt/Os ratios of eclogite and pyroxenite BMS extend toward higher values than peridotite BMS. They have systematically radiogenic ^{187}Os/^{188}Os$_{\mathrm{C}}$. Half the BMS have slightly radiogenic ^{186}Os/^{188}Os$_{\mathrm{C}}$, while the rest have very radiogenic to extreme ratios (0.1198557-0.1200785). Even more extreme ^{186}Os/^{188}Os$_{\mathrm{C}}$ have been obtained in Pt-rich alloys from ophiolites (up to 0.1217), confirming the potential of HSE carriers to generate highly radiogenic signatures within the shallow upper mantle. Melting of a mantle peridotite metasomatically enriched with BMS derived from pyroxenites or eclogites could explain the entire spectrum of the ^{187}Os-^{186}Os variation in plume-related lavas. Pt-rich alloys are a possible alternative to BMS being the key agent for dominating the ^{187}Os-^{186}Os characteristics of magma source regions, even if it is unclear whether their isotopic signature can be effectively transferred to mantle melts due to their refractory and chemically-inert nature. The coupled ^{187}Os-^{186}Os enrichment of the plume-related lavas can thus have an upper-mantle origin reflecting mantle sources that have experienced BMS metasomatism by pyroxenite and/or peridotite-derived partial melts. Thus these signatures cannot be taken as a unique indicator of core-mantle interaction.

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