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Tracking deep mantle melt infiltration through sulphide and HSE-Os systematics in Ligurian pyroxenite–peridotite associations (Italy)

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Deep melt infiltration and melt-peridotite interaction are fundamental mechanisms to generate chemical and isotopic heterogeneity in the upper mantle. These processes lead to the formation of pyroxenite-bearing peridotites and therefore play a key role in producing veined, enriched mantle sources commonly invoked to explain oceanic magmatism. Natural analogs of such pyroxenite-bearing fertile mantle are rare, and our understanding of processes governing the chemical modification of mantle sources by pyroxenite emplacement is still limited. Here, we present a comprehensive petrological and geochemical study of the well-characterized pyroxenite–peridotite associations from the External Liguride ophiolites (Italy) (e.g. Borghini et al., 2021), integrating whole-rock HSE abundances, Re–Os isotopes and in-situ analyses of single base-metal sulphides (BMS) along spatially constrained pyroxenite–peridotite profiles. These mantle sequences represent an exceptionally well-preserved record of deep (spinel-facies) melt infiltration and pyroxenite emplacement at ca. 430 Ma within ancient subcontinental lithospheric mantle. Peridotites exhibit near–primitive upper mantle HSE patterns and unradiogenic $^{187}Os/^{188}Os$ ratios, indicating that pyroxenite emplacement had little effect on bulk HSE systematics. In contrast, variations in sulphide distribution and composition along the profiles record interaction between infiltrating melts and the host peridotite, indicating that HSE mobility during melt percolation is primarily governed at the sulphide scale. Pyroxenites show wide variations in HSE abundances and Os isotopic compositions, defining three compositional groups correlated with major-element chemistry and layer thickness. Clinopyroxenites display strongly fractionated, melt-like HSE signatures, whereas websterites exhibit progressively less fractionated patterns approaching those of the host peridotite, consistent with increasing degrees of melt–peridotite interaction. Forward modelling suggests that the Pd/Ir systematics of the pyroxenites can be explained by variable degrees of sulphide mixing and reactive melt percolation. These results demonstrate that sulphides play a primary role in HSE redistribution during mantle melt migration and that sulphide-scale processes are critical for interpreting bulk-rock HSE–Os systematics in veined mantle domains, thereby providing new constraints on the development of mantle heterogeneities and the long-term chemical evolution of subcontinental lithospheric mantle domains.

Borghini et al. (2021): Enriched Hf–Nd isotopic signature of veined pyroxenite-infiltrated peridotite as a possible source for E-MORB. Chem. Geol. 586, 120591.