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Explore mantle heterogeneity through pristine dunite-channel systems in the Xigaze ophiolite

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Ongoing studies on oceanic lithosphere reveal extensive heterogeneity within the oceanic mantle. However, fully and comprehensively exploring the characteristics of this heterogeneity through current International Ocean Discovery Program remains challenging due to several factors, including the expensive costs of drilling, unavoidable sampling bias, limited availability of oceanic mantle samples across different geological epochs and tectonic settings, etc. A key mechanism for melt extraction in the mantle is via the high-porosity dunite-channel system (comprising reactive dunites and surrounding harzburgites). How can we leverage the deep, pristine dunite-channel systems in ophiolite to investigate oceanic mantle heterogeneity? Our previous studies [1-2] revealed the operation mechanism of dunite-channel systems (including three types of dunites and their wall-rock harzburgites) in the Xigaze ophiolite, a relic of oceanic lithosphere formed in a slow-ultraslow spreading center.

In this study, we present new isotopic data and HSE compositions from this system. The Os isotopic and HSE compositions reveal different geochemical characteristics among three types of dunites. Type 2 dunites exhibit narrow ranges of $^{187}Os/^{188}Os$ (0.11887-0.13001) and $^{187}Re/^{188}Os$ (0.018-0.036), along with more depleted HSE patterns. Type 1 and type 3 dunites, in contrast, show broader variations in $^{187}Os/^{188}Os$ (0.12658-0.15489 and 0.12640-0.15056, respectively) and $^{187}Re/^{188}Os$ (0.078-13.209 and 0.011-0.304, respectively), coupled with more enriched HSE signatures. Compared to the dunites, the wall-rock harzburgites display even greater variability in $^{187}Os/^{188}Os$ (0.11405-0.15549) and $^{187}Re/^{188}Os$ (0.016-1.424), alongside relatively enriched HSE characteristics. Notably, one harzburgite yields the oldest T_{RD} model age of 2.0 Ga, indicating the contribution of ancient mantle components. Hf-isotope data of Cpx from these dunites and harzburgites, when recalculated to the Xigaze ophiolite formation age at ~125 Ma, show $\varepsilon Hf_{(t)}$ spanning from -44.9 to +19.2, suggesting the complex channel-melt or melt-melt interaction history within the channel systems. These new isotopic and HSE data reveal that the pristine dunite-channel systems of slow-ultraslow spreading centers can preserve original and highly variable isotopic signals, possibly derived directly from the asthenosphere source, which make them promising targets for exploring the scale and extent of oceanic mantle heterogeneity.

[1] Wang et al. (2024) Lithos 468-469, 107501; [2] Wang et al. (2025) Manuscript in preparation.