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Preservation of Midproterozoic ^{187}Re–^{187}Os melt-depletion ages in Paleozoic oceanic mantle: North Arm Mountain, Bay of Islands Ophiolite Complex

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Highly siderophile element (HSE) abundances and Re–Os isotope systematics constrain the timing and extent of mantle melt depletion, but the spatial scale over which these signatures are preserved remains poorly defined. Whether mantle circulation homogenizes Re–Os isotopic heterogeneity or allows ancient depletion signatures to persist is still unresolved. We present new petrological and HSE and Re–Os isotope data from harzburgites sampled in ~10 m² grids in the lower Paleozoic North Arm Mountain (NAM) mantle section of the Bay of Islands Ophiolite Complex. This grid-based sampling strategy allows integration of field relationships and geochemical signatures across multiple length-scales.

Spinel–olivine thermometry yields equilibration temperatures of ~920 °C. Calculated oxygen fugacities (ΔQFM) are –4.2 to –1.2 (1.5 GPa) and overlap between grids, indicating no systematic redox difference. In contrast, spinel Cr# (Cr/(Cr+Al)) varies clearly between grids, ranging from ~0.30 to ~0.60. Grids with lower Cr# are characterized by relatively high Yb_N (0.08–0.11) and lower $(La/Yb)_N$ (0.03–0.07), consistent with strongly depleted residual signatures. Grids with elevated Cr# exhibit lower Yb_N (0.04–0.06) and higher $(La/Yb)_N$ (0.16–0.20), and are distinguished in the field by dunite and pyroxenitic channels, consistent with enhanced melt focusing and melt–rock interaction. Harzburgites generally reveal depleted REE patterns consistent with 11–20% fractional melting of a depleted mantle source.

HSE ratios further differentiate the grids: more refractory grids (low Cr#) have low Pd/Ir and Re/Ir (<0.01), while melt percolation-affected grids (elevated Cr#) have higher PPGE/IPGE ratios (Pd/Ir up to ~3) and Re/Ir. Re–Os isotope data define tightly clustered Re-depletion (T_{RD}) and model (T_{MA}) ages within grids, with two grids recording Midproterozoic melt-depletion ages despite incorporation into a lower Paleozoic mantle section. Low Re abundances (<0.1 × PM) support negligible post-depletion Re addition and the robustness of Os isotopic signatures.

The decoupling between present-day melt depletion indices and isotopic depletion ages indicates that ancient refractory mantle domains can survive later melt extraction and melt-rock reaction without isotopic homogenization. Our results constrain the minimum spatial scale over which chemical depletion and Os isotopic signatures remain coherent in the convecting upper mantle to decameters.