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Multi-Stage Subduction Metasomatism and Mantle Redox Evolution Recorded by Orogenic Peridotites from the Ulten Zone (Italian Alps)

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Orogenic peridotites from Ultra-High-Pressure (UHP) terranes preserve direct records of subduction-related metasomatism and mantle redox evolution. Our study investigates peridotites from the Ulten Zone (Upper Austroalpine) that experienced Variscan continental collision. The sample suite comprises peridotites from multiple lenses, including previously unstudied bodies, and captures progressive transformation from spinel peridotites (~1200 °C; 1.5 GPa) that underwent mantle wedge corner flow into garnet peridotites (850 °C; 3 GPa) during subduction and exhumation within subducted continental slab. We present whole-rock trace element, non-traditional stable metal isotopes (δ^{66}Zn, δ^{56}Fe) data and high-precision in situ synchrotron Mössbauer spectroscopy analyses of Fe^{3+} in major and metasomatic minerals.

Major element compositions (Al_2O_3 = 1.2–3.6 wt%; MgO = 38.2–44.9 wt%) reflect variable fertility. Spinel peridotites display slight LREE enrichment and fractionated δ^{66}Zn values down to -0.20 ± 0.04‰, consistent with interaction with carbon-bearing slab-derived fluids during an early metasomatic stage, supported by dolomite inclusions preserved in spinel within garnet. Garnet peridotites exhibit elevated and variable LREE enrichment (La_N/Yb_N = 1.10–11.13) positively correlated with Ba, indicating continued subduction input. Negative correlations of LREE/HREE with U/Th and Pb/Ce ratios suggest preferential transport of Th over U and Ce over Pb during the spinel-to-garnet transition, consistent with supercritical fluid metasomatism. δ^{56}Fe values range from -0.18 ± 0.05‰ to 0.11 ± 0.02‰ and correlate with Pb/Ce in garnet peridotites, recording Fe isotope fractionation during this second stage. Mössbauer derived Fe^{3+} contents enable quantification of oxygen fugacity evolution across both metasomatic events. Collectively, these results provide new constraints on the chemical and isotopic modification of the mantle wedge and reveal the fundamental role of subduction-related metasomatism in the mantle redox evolution at sub-arc depths.