

Redox Transfer at Sub-Arc Mantle: Insights from Petrology and Transitional Metal Stable Isotope (Fe, Zn, Cu) Geochemistry of Orogenic Peridotites

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The mantle wedge above subduction zones is often considered more oxidized (i.e., exhibiting higher oxygen fugacity (fO_2)) than other mantle domains due to metasomatism by slab-derived fluids. Garnet peridotites from subduction zones, for instance, record oxygen fugacities that are 3–4 log units higher than those of garnet peridotite xenoliths from the sub-cratonic mantle. However, no direct link has yet been established between the fO_2 record and the transfer of redox-sensitive components (e.g., SO_4 , CO_2) from the subducted slab to the mantle wedge, and the fate of subducting oceanic lithosphere remains poorly constrained.

In this study, we conduct a detailed petrologic and geochemical investigation of garnet peridotites from the Adula-Cima-Lunga unit (Alpe Arami, Cima di Gagnone, and Monte Duria). These peridotites, which all equilibrated under different P-T conditions, are particularly significant due to the ongoing debate over their geodynamic origins. Previous studies suggest that the Cima di Gagnone peridotites correspond to the subducted serpentized slab, whereas the origins of the Alpe Arami and Monte Duria peridotites remain uncertain—they could represent either the metasomatized mantle wedge or the subducted slab.

We present high precision in-situ synchrotron Mossbauer source Fe^{3+} measurements on major and metasomatic minerals (garnets, clinopyroxenes and amphiboles) in the peridotite samples. The results enable us to model the fO_2 record and constrain the redox reactions occurring during fluid/rock interactions in the context of subduction. Additionally, trace element and non-traditional stable metal isotope (Fe, Zn, Cu) geochemistry provide key insights into the transfer of redox-sensitive elements in subduction zones while also helping to clarify the geodynamic origins of the studied peridotites. Thus, we attempt to correlate the redox record of the sub-arc mantle, using Fe^{3+} measurements at the mineral scale, with whole-rock geochemical data in order to characterize the relative effects of subduction-fluids on the composition and oxidation of the mantle wedge peridotites.