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Mantle Oxidation Driven by the Redox Dynamics of the Mariana-Type Subduction

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Oceanic plates descending into subduction zones transport a significant amount of oxidized material to both the subduction zone and the Earth's deeper layers (Wood et al. 1990). However, the specific mechanism of mass transfer and the corresponding flux released at different depths remains unclear. Through the use of numerical modeling and a coupled geochemical database, we examined redox dynamics in subduction zones, particularly focusing on Mariana-type subduction zones, representative of the modern plate tectonic regime (Yao et al., 2021).

Our findings highlight two primary mechanisms in the mantle oxidation processes related to subduction. Firstly, desulfurization enables subduction fluids to carry substantial oxidation fluxes into the sub-arc mantle. Mass balance calculations emphasize the sufficiency of these fluxes in oxidizing both the arc magma and mantle wedge, with the hydrated mantle being the primary fluid contributor, followed by the altered oceanic crust. Secondly, partial melting of slab-top rocks, where Fe^{3+}-rich melts from sediments and altered oceanic crust play a predominant role in the oxidation of the back-arc mantle. Importantly, during Mariana-type subduction, the majority of oxidation fluxes penetrate the deeper mantle with subducting slabs. According to our models, we illustrate that during the modern era of plate tectonics, the oxidation fluxes generated by Mariana-type subduction zones had a significant global impact on Earth's mantle redox evolution and the oxygenation of our planet.

References

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