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Mantle wedge oxidation due to sediment-infiltrated deserpentinisation

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Interaction of seawater with the oceanic lithosphere results in alteration of the oceanic crust and hydration of mantle peridotite to serpentinite. Serpentinisation substantially increases the amount of water and the ferric iron over total iron ratio relative to that of the Depleted MORB Mantle, placing serpentinite among the most oxidised and volumetrically important rocks of the altered oceanic lithosphere. Seafloor serpentinisation furthermore increases the content of redox-sensitive, multivalent elements, particularly sulphur, whose abundance varies by up to three orders of magnitude relative to DMM, reflecting a large variability of oxygen fugacity (fO_2) and S intake processes. The potential role of deserpentinisation aqueous fluids as oxidation agents of the mantle wedge source of arc magmatism, accounting for the more oxidised nature of arc basalts relative to MORBs, has received much attention in the last decade with highly contrasted views.

Thermodynamic modelling, experiments, and metaperidotite study in exhumed high-pressure terrains result in differing estimates of the redox state of deserpentinisation fluids, ranging from low to highly oxidant. Using thermodynamic and mass balance modelling, here we show[1] that although intrinsic deserpentinisation fluids are highly oxidant, the infiltration of small fractions of external fluids equilibrated with metasedimentary rocks strongly modulates their redox state and oxidation-reduction capacity, explaining the observed discrepancies in their redox state. Infiltration of fluids equilibrated with graphite-bearing sediments reduces the oxidant, intrinsic deserpentinisation fluids to oxygen fugacities similar to those observed in most graphite-furnace experiments and natural metaperidotites. However, infiltration of CO_2-bearing fluids equilibrated with modern GLOSS generates sulphate-rich, highly oxidising deserpentinisation fluids. We show that such GLOSS-infiltrated deserpentinisation fluids can effectively oxidise the mantle wedge of cold to hot subduction zones, potentially accounting for the presumed oxidised nature of the source of arc basalts.

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