Sulfate- and carbonate-driven oxidation of the sub-arc mantle – insights from orogenic garnet peridotites of Norway

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Oxybarometric calculation show that lavas at convergent plate margins are, on average, more oxidised than mantle-derived magma from other tectonic settings. One way of oxidising the source of arc lavas in the mantle wedge is the addition of oxidised species, such as S^{6+}, C^{4+} and possibly Fe^{3+} in slab-derived fluids. If so, this requires an efficient transport mechanism of these into the overlying mantle wedge. However, the remote nature of these processes render direct investigations impossible, and little is known about the plausible reduction-oxidation mechanisms at sub-arc P-T-X (pressure-temperature-composition) conditions.

Here, we study the mineralogy and chemistry of orogenic peridotites from the Western Gneiss Region of Norway. These mantle sections are considered to be parts of supra-subduction mantle that are chemically altered by fluids at high to ultra-high P, evidenced by the presence of metasomatic majoritic garnet and diamond, and consistent with P-T conditions close to the slab-wedge interface. The presence of sulfate and carbonate in meter-scale, metasomatic veins indicate addition of oxidised fluids. Reaction with ambient mantle caused oxidation via an increase in $Fe^{3+}/\sum Fe$, evidenced by domains with hematite-rich inclusions, and reduction of fluid-borne sulfate and carbonate to precipitate sulfides and graphite. *In-situ* analyses of these metasomatic sulfides revealed S isotope signatures inconsistent with derivation from mantle sulfides, and most plausibly related to slab-derived S. This result is consistent with platinum group element patterns in the same sulfides.

We propose a model for efficient transfer of oxidation potential from the slab to the loci of arc melting in which slab fluids can travel in self-oxidising channels. Therein, wall-rock oxidation may shield fluids from the mantle ferric-ferrous buffer, thus providing effective pathways for transfer of oxidised fluids. Our study therefore supports a link between S and C subduction cycles and oxidation of arc magmas via a network of oxidised sub-arc fluid/melt channels.