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Experimental constraints on orthopyroxene dissolution in subduction-zone fluids at serpentine-out pressure–temperature conditions

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Fluids released from the subducting slab drive metasomatism in the mantle wedge. While mantle mineral-fluid interactions associated with serpentinization are well-constrained, those at pressures and temperatures exceeding the serpentine stability field remain poorly understood, particularly regarding the influence of Fe and Al. Current thermodynamic modeling[1,2] predicts that the dissolution of Fe-bearing orthopyroxene at serpentine-out conditions (e.g., 1.5 GPa, 800°C) produces magnetite and fluids containing readily escaping hydrogen, potentially oxidizing the mantle-wedge rocks and providing an explanation for the origin of oxidized arc magmas. We tested this hypothesis using *in situ* hydrothermal diamond anvil cell experiments combined with Raman spectroscopy on synthetic Fe-free, natural Fe-bearing (Mg# = ~90), and natural Al-Fe-bearing enstatite (3.4 wt% Al_2O_3) up to around 2.0 GPa and 850°C. Contrary to the thermodynamic modeling, all enstatite samples dissolved incongruently to produce olivine and silicate-bearing fluids without observable magnetite or clinochlore precipitation. Notably, Fe-bearing enstatite exhibited markedly lower apparent solubility than the other two variants. The lack of magnetite suggests that H_2 production via orthopyroxene hydration may be inhibited by Fe-partitioning into olivine. Consequently, the deep mantle wedge may be less oxidized by slab fluids than thermodynamic modeling suggests, with implications for redox budgets and arc magma genesis in subduction zones.

[1] Connolly JAD. Computation of phase equilibria by linear programming: A tool for geodynamic modeling and its application to subduction zone decarbonation. *Earth Planet Sci Lett* 2005;236:524–41.

[2] Sverjensky DA, Harrison B, Azzolini D. Water in the deep Earth: The dielectric constant and the solubilities of quartz and corundum to 60 kb and 1200 °C. *Geochim Cosmochim Acta* 2014;129:125–45.