Can Slab Fluids Oxidize the Sub-arc Mantle?

KAYLA IACOVINO[1]* AND CHRISTY B. TILL[1]

[1]School of Earth and Space Exploration, Box 876004, Tempe, AZ 85287-6004 (*kayla.iacovino@asu.edu)

Lavas and gases erupted at arc volcanoes are widely observed to be the most oxidized on Earth, but the mechanism(s) responsible for their elevated redox state remain hotly debated. One frequently cited explanation calls on the flux of aqueous fluid derived from the breakdown of hydrous minerals within the down-going slab to catalyze mantle melting and impose an oxidized redox signature on the mantle wedge [1–2]. Here we present the results from experiments and modeling designed to investigate fluid-mediated element transfer, including redox reactions, at the slab-mantle interface. These data include the first direct measurements of the oxygen fugacity of fluids released during the experimental breakdown of natural antigorite serpentinite at 1 GPa and 800 °C, analogous to the conditions in subducting slabs below arcs. These experiments indicate that the dehydration of natural antigorite produces solute-rich and oxidizing (QFM+2) fluids with compositions similar to those measured in fluid inclusions in exhumed ultramafic terrains (e.g. for Na, K, Ca, Sr [3]).

Theoretical chemical mass transfer calculations were used to investigate the metasomatism of a MORB-source mantle (Fe^{3+}/Fe^{tot} = 0.13) by slab fluids with compositions matching those synthesized in experiments. The modeling indicates that this process can produce a range of observed mantle lithologies from magnetite-rich garnet pyroxeninte to lherzolite with decreasing fluid/rock ratio. Moderate fluid/rock rations (<0.1–10) during metasomatism results in peridotites with elevated Fe^{3+}/Fe^{tot} (0.15-0.35), matching the ratios observed in sub-arc mantle xenoliths (0.27-0.44 [4]) and primitive arc basalts (0.18-0.5 [2,5]). The addition of oxidizing sulfate and/or carbonate species to slab serpentinite assemblages enhances this effect and can generate fluids with oxygen fugacities above the hematite-magnetite buffer [6]. These new data support the hypothesis that metasomatic alteration by slab fluids may effectively oxidize the sub-arc mantle and contribute to the genesis of oxidized arc magmas.

[1] Wood et al. (1990) *Science* **248**, 337 [2] Kelley & Cottrell (2009) *Science* **325**, 605 [3] Scambelluri et al. (2004) *EPSL* **222**, 217-234 [4] Brandon & Draper (1996) *Geochim Cosmochim Acta* **60**, 1739-1749 [5] Grocke et al. (2016) *EPSL* **440**, 92-104 [6] Debret & Sverjensky (2017) *Nature Sci. Reports* **7**: 10351