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Oxidized slab fluids recorded by sulfur-in-apatite: A case study from Syros, Greece

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Arc magmas and the subarc mantle exhibit an elevated oxygen fugacity (fO_2) relative to their mid-ocean ridge equivalents, which has been used to infer an oxidized slab source. Sulfur is one of the few abundant and mobile redox-sensitive elements capable of raising the fO_2 of arc magmas; however, studies have proposed slab fluids are dominated by reduced (S^{2-}) or oxidized species (S^{6+}). Here we use *in situ* X-ray absorption spectroscopy analysis of sulfur in apatite to monitor redox processes during high-P fluid-rock interaction. We sampled a 67 cm transect of reaction zones between an eclogite block and serpentinite matrix on Syros, Greece. The block core preserves a prograde to peak assemblage of garnet, omphacite, phengite, paragonite, epidote-clinozoisite, and rutile. Outward from the core, reaction zone assemblages are (Zones 1–3) omphacite + epidote-clinozoisite + rutile ± garnet ± apatite, (Zone 4) Ca-Na amphibole + omphacite + chlorite + pyrite + apatite, (Zone 5) Ca-Na amphibole + chlorite + pyrite + apatite, (Zone 6) Ca amphibole + chlorite + pyrite + apatite, and (Zone 7) Ca amphibole + talc + pyrite.

Prograde apatite matrix grains and inclusions in the block core and recrystallized eclogite assemblage (Zones 1–3) display only S^{6+} in their absorption spectra, proving sulfate stability during prograde to peak metamorphism and high-P metasomatism. Apatite in the pyrite-rich (~1–5 vol % pyrite) Ca-Na amphibole + omphacite + chlorite assemblage displays mixed S^{1-} and S^{6+} to S^{1-} only spectra, whereas apatite in the distal Ca amphibole + chlorite + pyrite assemblage display S^{6+} spectra. The outward transition from S^{1-} to S^{6+} in apatite in the amphibole-bearing assemblages occurs over a dramatic decrease in Na content and increase in Mg#. We propose that the change in Fe over this interval drove the reduction of S^{6+} in the infiltrating fluid to form S^{1-} in pyrite and apatite, as balanced by the oxidation of Fe^{2+} to Fe^{3+}. In summary, these data demonstrate that oxidized S-bearing slab fluids were present during multiple stages of metamorphism and metasomatism on Syros – fluids of the type that can oxidize the subarc mantle and lead to oxidized arc magmas.