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The oxidation state of Fe and S in Galapagos Archipelago lavas and the redox characteristics of PHEM

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The oxidation states of iron recorded in young ocean island basaltic glasses varies by more than a factor of three. Recently, this has been qualitatively and variably attributed to 1) the presence (or lack) of recycled surface materials in some ocean island mantle sources, 2) contributions from a shared component generated in Earth's lower mantle, and/or 3) high pressure mantle melting. Here we report new measurements of the oxidation states of iron and sulfur in submarine basaltic glasses dredged from the Galapagos archipelago. Galapagos glasses have 0.138-0.193 Fe^{3+}/TFe and 0.08-0.34 S^{6+}/TS. We correct for the effects of low-pressure differentiation and Fe-S redox chemistry on Fe and S oxidation states and calculate oxygen fugacities of least differentiated magmas and modeled primary melts at the pressures and temperatures of melt segregation from the asthenosphere. By leveraging large, pre-existing datasets collected on the same glasses, we show that 1) there are statistically significant positive correlations between Fe oxidation state and indices for the presence of recycled surface materials in the mantle sources (e.g., $^{87}Sr/^{86}Sr$) of some Galapagos glasses, 2) the Fe oxidation state of these glasses are uncorrelated with indices for isolated lower mantle-derived materials (e.g., $^{3}He/^{4}He$, PHEM), and 3) there are statistically significant positive correlations between Fe oxidation state and trace element indices for mantle melting at high pressures in the garnet stability field (e.g., Sm/Yb). Using a simple mixing model, we demonstrate that the Fe oxidation state of the recycled surface materials present in the Galapagos mantle may be significantly less oxidized that similar materials present in the mantle sources of Hawaiian, Icelandic, Canary and Cape Verde Islands, and Erebus magmas. This implies that ocean island basalts contain a complex, rich record of variable redox states of ancient surface derived materials.