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Linking sulfur degassing and magmatic redox at Socorro and San Benedicto Islands, Mexico

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Oxygen fugacity (fO_2) is important for understanding mantle conditions that lead to magma generation, and the varied histories of heterogeneous mantle source rocks. Seeing through magmatic effects on fO_2, such as crystallization and degassing, is therefore vital to accurately constraining the fO_2 of mantle source rocks using mantle-derived magmas. The Revillagigedo Archipelago offers a unique opportunity to test degassing effects on magmatic fO_2 at Socorro and San Benedicto islands, two large intraplate shield volcanoes that span a large range in water depth. We have analyzed pillow glass and olivine-hosted melt inclusions from these islands and regional seamounts for major, trace, and volatile elements (EPMA, LA-ICPMS, FTIR), in addition to Fe-speciation (XANES). These data show the $Fe^{3+}/\sum Fe$ ratios in these magmas vary from 0.174 to 0.129, coincident with eruptive water depth (3900 to 250 m) and the extent of sulfur degassing (1385 to 567 ppm). A single, minimally degassed melt inclusion from San Benedicto (1700 ppm CO_2) indicates an entrapment pressure of ~2 kb and fO_2 of ~QFM+0.2. Importantly, this least-degassed composition is the most oxidized ($Fe^{3+}/\sum Fe = 0.191$) but remains consistent with the fO_2 of regional MORBs [1], suggesting magma formation at MORB-like conditions despite the ocean island setting of these volcanoes. However, low S pillow glass from the Mathematician Ridge does not reflect the same trends defined by the islands, suggesting the larger S budget of young regional volcanism could be from tapping a distinct mantle source composition, or from assimilation of a S-rich lithology within the crust. Ultimately, fO_2 decreases with water depth and extent of S degassing by an order of magnitude, demonstrating their coupled behavior in magmatic systems. This result is consistent with observations of highly reduced gases emitted at the summit fumarole of Cerro Evermann on Socorro [2], and with observational links between S loss and magmatic redox at other volcanoes [3]. We also see an extension of the S-redox trend past 1000 m depth, which strongly suggests S degasses at higher hydrostatic pressures than current models indicate.

[1] Zhang et al., 2018

[2] Taran et al., 2002

[3] Moussallam et al., 2014