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Oxidation State of the Mantle Inferred from 89 Ma Komatiites

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Oxygen fugacity (fO_2) is an important intensive variable in petrology, affecting the behavior of redox sensitive elements during magmatic processes. Evaluating the fO_2 of the modern mantle is critical for understanding geochemical cycling in the solid Earth. Sulfur degassing can have a strong effect on the fO_2 of emplaced lavas [1], complicating determination of source region fO_2. High degree partial melts, such as komatiites, are undersaturated in sulfur, and, thus, can be used to obtain more accurate estimates of the oxidation state of the modern mantle.

Gorgona Island in Colombia contains a rare example of 89 Ma komatiites that have been the subject of extensive geochemical studies [e.g., 2]. The oxidation state of a single well-preserved komatiite lava flow on the east coast of the island was evaluated using V-paritioning behavior between liquidus olivine and the komatiite magma [3-4]. Based on incompatible behavior of Cu during lava differentiation, the Gorgona komatiites were sulfur undersaturated upon emplacement, and, thus, did not undergo sulfur degassing. The flow was found to have an fO_2 = +0.45±0.15 ΔNNO log units. This value is somewhat higher than fO_2 estimates for modern MORB at −0.60±0.18 ΔNNO log units [5], the latter likely reflecting the influence of sulfur degassing, but is similar to that for modern Kilauea lavas of 0±0.12 ΔNNO log units [1] after correction for sulfur degassing is applied.

Recycling of oceanic crust and metasomatism can have an effect on the fO_2 of the mantle. However, it is unlikely that any significant amount of recycled crust was incorporated into the source of Gorgona komatiites or their source was metasomatically altered, as the komatiites show large depletions in incompatible trace elements [2]. Subduction zone lavas have been found to have higher fO_2 values, however, paleogeographic evidence demonstrates that Gorgona komatiites likely formed in a mantle-plume [2]. Thus, the measured fO_2 is considered to be an accurate estimate of the oxidation state of the 89 Ma mantle.

[1] Moussallam *et al.* (2016) *Earth Planet. Sci. Let.* 450, 317-325. [2] Kerr (2005) *Lithos* 84, 77-101. [3] Nicklas *et al* (2016) *Chem. Geol.* 433, 36-45. [4] Canil (1997) *Science* 389, 842-845. [5] Cottrell and Kelley (2011) *Earth Planet. Sci. Let* 305, 270-282.