Oxygen fugacity of forearc peridotites from the Tonga Trench: Implications for mantle processes during subduction initiation

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The forearc region of subduction zones records the complex set of melt-related processes associated with subduction initiation. Lavas associated with the forearc include MORB-like tholeiitic basalts, low-Ti boninites, and hydrous arc-like basalts [1]. The Tonga Trench, however, is unusual among convergent margins in that peridotites have been dredged from the forearc, presenting a unique opportunity to trace the effects of multiple types of melting and melt-rock interaction on residual mantle.

Oxygen fugacity (fO_2) is an important control on mantle melting processes, including volatile speciation and phase stability. Previous studies have shown that subduction zone magmas are more oxidized than MORB [2]; however, debate exists as to whether the mantle wedge itself is oxidized [3].

Oxygen fugacity measurements from the Tonga peridotites are heterogeneous between dredges along almost 1000 km of the trench's length, suggesting a complex history in the forearc. Results from one dredge show fO_2 values ranging from -0.5 to +0.5 log units relative to the QFM buffer, slightly elevated compared to the ridge peridotite average of QFM -0.88 ± 0.72, with spinel Cr#s ranging from 0.45 to 0.75. This data, combined with low TiO_2 concentrations in spinel, is suggestive of interaction between a refractory ridge-like peridotite and boninitic melt. In contrast, several other dredges along the trench record lower Cr#s with fO_2 elevated by ~1 log unit relative to the mid-ocean ridge peridotite array. This suggests oxidation of a more fertile source, while elevated spinel TiO_2 concentrations in dunites from these dredges are consistent with later melt-rock interaction with a hydrous arc-like magma.

[1] Meffre et al., *Geochemistry, Geophysics, Geosystems* (2012); [2] Kelley et al., *Science* (2009); [3] Lee et al., *Journal of Petrology* (2005)