The oxidation states of iron and volatile compositions of Expedition 352 glasses

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The subduction of oceanic lithosphere is linked to the production of hydrous arc basalts that are enriched in key trace elements (e.g., Ba) and have higher proportions of oxidized iron than mid-ocean ridge basalts [1]. To constrain the timing and mechanisms of the initiation and maturation of subduction on magma genesis, we analyzed volcanic glasses recovered from IODP Expedition 352 to the Izu-Bonin-Mariana forearc for Fe3+/∑Fe ratios (XANES) and major, trace and volatile element contents. The oldest recovered lavas are forearc basalt (FAB) with ages of 51.9 to >51.3 Ma [2]. The FAB glasses (3.34-8.74 wt% MgO) have H2O from 0.18-0.85 wt%, CO2 from 75-233 ppm, S contents controlled by saturation with a sulfide phase (602-1386 ppm), Ba/La ratios from 3.9-10, and Fe3+/∑Fe ratios from 0.136-0.177. These H2O-CO2 contents suggest eruption on the seafloor in deep water (~3700 mbsl). These compositions are similar to that of MORB, and suggest that decompression melting of dry, depleted, and reduced mantle dominates the earliest stages of subduction initiation. These rocks are followed stratigraphically by boninitic lavas (>51.3 Ma to 50.3 Ma; 0.23-7.75 wt% MgO) [2], with H2O from 1.51-3.19 wt%, CO2 below detection via FTIR, S contents below that required for sulfide saturation (5-235 ppm), Ba/La ratios from 11-29, and Fe3+/∑Fe ratios from 0.181-0.225. These H2O-CO2 also suggest eruption on the seafloor at ~3800 mbsl. These data demonstrate that, once initiated, subduction proceeds rapidly, and many of the characteristic features of arc volcanism (hydrous, trace element enriched, and oxidized) are established via fluid-fluxed melting of the mantle in just 0.6-1.2 my. The production of different Fe3+/∑Fe ratios in FAB and boninites over a relatively short time span, as well as the coherence of high Fe3+/∑Fe and Ba/La ratios with high H2O contents, suggest the production of oxidized arc basalts is linked to signatures of slab dehydration [3].

[1] Brounce et al. (2014) J Pet 55, p. 2513-2536 [2] Reagan et al. (2019) EPSL 506, p. 520-529 [3] Brounce et al. (2015) Geology 43, p. 775-778