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Young off-axis boninitic volcanism at the Valu Fa Ridge (Lau Basin) indicates depleted hydrous mantle beneath the back-arc

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Seamount 3 (Smt. 3) is a young volcanic seamount located ~5 km east of the actively-spreading southern Valu Fa Ridge (VFR) in the Lau back-arc basin. We present new mineral, whole-rock major, trace element, and Pb–Sr–Nd–Hf isotope data for lava samples from Smt. 3. The whole-rock compositions reflect mixing of less primitive melt with variable amounts of early-crystallized olivine, and quenched glass compositions result from crystal fractionation of a primitive boninitic magma which is preserved as melt inclusions hosted in olivine crystals. The compositions of primitive olivine and spinel from Smt. 3 are more refractory than those from MORB and BAB lavas. The lower Fe8, Ti8 and Na8 values than those of other spreading ridges in the Lau Basin which are located further from the active arc, suggest high temperature and low pressure melting of relatively depleted mantle. The mantle beneath Smt. 3, the adjacent VFR and the arc-front volcano Ata which is situated 35 km to the east, is more depleted than that beneath back-arc spreading centres to the north. Smt. 3 lavas have similar slab fluid and higher slab melt input than those of Ata, and higher slab contribution compared to the nearby Valu Fa. The trace element modeling suggests that the Smt. 3 magma is the result of high degree of partial melting (~30%) of mantle which was previously depleted by 0.1–0.3% melting compared to the source of mid-ocean ridge basalts. The geochemical characteristic differences between VFR and Smt. 3 implies a heterogenous melting zone with the boundary between dry and wet mantle lying west of Smt. 3. Because of convection in the hydrous mantle with low viscosity, the mantle has been repeatedly depleted by partial melting but also affected by transported slab components into the off-axis melting zone, before undergoing high degrees of partial melting at low pressure to form boninitic primitive melt.