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Evidence from melt inclusions for magmas stalling at mid-crustal depths

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Primitive porphyritic basalts containing wehrlite and dunite crystalline aggregates were recovered from the northwestern slopes (1390-1135 mbsl) of West Zealandia Seamount (˜16^{o} 53' N), southern Mariana Arc, by the ROV Hyper-Dolphin during cruise NT09-08, in June 2009. Olivines within the wehrlite (Fo_{83-90}) and dunite (Fo_{84-91}) aggregates, and the phenocryst population (Fo_{77-82}) contain glassy silicate melt inclusions. The compositions of these olivines and the volatile contents of the inclusions they host (analyzed by electron microprobe, laser ablation inductively coupled plasma mass spectrometry and micro-Fourier-transform infrared spectroscopy) suggest a crustal origin for the aggregates. Maximum H_2O and CO_2 contents in inclusions from olivine in the wehrlite aggregates of 4.23 wt.% and 809 ppm, respectively, suggest final equilibration at ˜300 MPa, equivalent to depths of ˜11 km. Inclusions in the dunites and phenocryst olivine populations are more evolved and contain maximum H_2O and CO_2 contents of 4.52 wt.% and 402 ppm, respectively. These suggest final equilibration at ˜180 MPa, equivalent to depths of ˜6 km. Geophysical surveys of the crustal structure in this area of Mariana Arc estimate the total thickness of the crust beneath West Zealandia to be ˜19 km, with lower-middle crust and middle-upper crust boundaries at ˜11 and ˜6 km, respectively. These correspond to the inclusion equilibration depths suggesting that magmas are stalling at these boundaries and trapping melts as they crystallize. Comparison with volatile contents in other melt inclusions suggests that magmas commonly stall at 6 to 12 km beneath Mariana Arc volcanoes, and indeed beneath volcanoes in other arcs. This has important implications as it may represent a fundamental relationship between magma stalling, differentiation and the generation of middle crust in the Izu-Bonin-Mariana Arc system and other arcs.

Keywords: melt inclusions, volatiles, middle crust