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Evidence for wehrlite and dunite xenoliths from West Zealandia Seamount, Mariana Arc, originating in the middle crust

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West Zealandia Seamount (˜16^o 53’ N) lies behind the magmatic front of the Mariana Arc. Sampling of the northwestern slopes from 1390-1135 mbsl with the ROV Hyper-Dolphin during NT09-08 in June 2009 recovered primitive porphyritic basalts containing dunite and wehrlite crystalline aggregates. Olivines within the aggregates contain glassy silicate melt inclusions. Firstly, major elements in the crystals forming the aggregates were analyzed by electron microprobe (EPMA) to determine whether the aggregates are mantle xenoliths. Crystals forming the phenocryst and groundmass population were also analyzed.

On the basis of olivine-spinel compositional relationships, spinels in aggregate olivines may have crystallized in the mantle. High Mg# (>91) and Na_2O/TiO_2 (>2.05) in aggregate clinopyroxenes suggest the wehrlites formed at high pressure, with clinopyroxene phenocrysts and groundmass crystals forming at successively lower pressures from increasingly evolved melts. Aggregate olivines (Fo_{85-90}, NiO 0.10 to 0.17 wt.%, CaO >0.15 wt.%) are distinct from those of the mantle (NiO 0.28 to 0.36 wt.%, CaO <0.10 wt.% at these Fo contents), but the high Fo contents suggest crystallization from a primitive melt. The olivine phenocryst population include a number of crystals that share geochemical characteristics with the aggregates, suggesting that these are fragments of aggregates. Furthermore, spinels hosted in these olivine phenocrysts have much higher Cr# (76) than spinels in other phenocrysts (Cr# <5), and together with the high host phenocryst Fo content (91) this results in them falling in the olivine-spinel mantle array along with those from the aggregates.

In order to better constrain crystallization depths we have estimated the entrapment pressures and compositional evolution of the glassy silicate melt inclusions found in the olivines. Dissolved volatile contents have been measured by micro-Fourier-transform infrared spectroscopy (FTIR) and the major element contents of the inclusions and the their hosts have been measured by EPMA. The olivine hosts range from Fo_{80-89}, NiO 0.06 to 0.30 wt.% and CaO 0.13 to 0.22 wt.%. The compositional range suggests that inclusions hosted by crystals from both the aggregate and phenocryst populations have been sampled. After correction for post-entrapment crystallization, the inclusions contain 46.08 to 50.65 wt.% SiO_2, 4.16 to 8.46 wt.% MgO, 0.59 to 1.14 wt.% TiO_2 and 0.17 to 0.42 wt.% K_2O. At these SiO_2 contents, the K_2O contents are low for the magmatic front of the Mariana Arc. In addition SiO_2 contents do not correlate strongly with MgO contents, with a group of inclusions largely from the wehrlite olivines characterized by high MgO (7.26 to 8.46 wt.%) and high SiO_2 (49.02 to 50.65 wt.%). Corrected inclusion H_2O contents range from 2.91 to 4.27 wt.%, with the exception of one inclusion containing 1.74 wt.%, while CO_2 contents range from below detection (59 ppm) to 764 ppm. Overall the H_2O-CO_2 systematics are consistent with open system degassing, with entrapment pressures estimated to range from 33 to 298 MPa. Entrapment pressures correlate with melt inclusion MgO content and host Fo content and indicate that inclusions in the wehrlite olivines were trapped from the most primitive melts at the deepest pressures. These are equivalent to depths of ˜11 km, which approximate to the lower-middle crust boundary beneath West Zealandia, suggesting that the wehrlite aggregates may sample cumulates that formed in a magma chamber developed at this boundary in the crust. Inclusions in the dunite aggregates and phenocrysts were trapped later, after the melt had evolved, at pressures equivalent to ˜6 km bsl, suggesting that a shallower magma chamber also exists at the middle-upper crust boundary.

Keywords: olivine, melt inclusions, major elements, water, carbon dioxide