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Pickling Peridotites in the IBM Mantle Wedge: Inferences from the Guguan Cross-Chain, Mariana Arc

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Variations in lava compositions observed in arc ‘cross-chains’ reveal chemical and isotopic gradients resulting from ‘pickling’ of convecting asthenosphere by fluids and melts from the descending slab. This can be studied using lavas from arc cross-chains. We report geochemical and isotopic data for basalts and basaltic andesites from the Guguan cross-chain at 17°15'N in the Mariana Arc, comprising the active volcanic island Guguan (and submarine cone N. Guguan) along the magmatic front (~125 km above the subducted slab) and two seamounts to the west, W. Guguan (~150km) and Guguan II (~230 km). Guguan lavas represent the ‘fluid-dominated’ endmember of Mariana arc lavas, and comprise fractionated basalts, basaltic andesites, and subordinate andesites (Mg# = 35-51, Ni<30ppm). Lavas from N. Guguan seamount consists of less fractionated basalts (Mg# = 52, ~50ppm Ni). Basalts from W. Guguan (Mg# = 61, 60-80 ppm Ni) and Guguan II (Mg# = 63-75, 100-400 ppm Ni) are much less fractionated. Guguan, N. Guguan, and W. Guguan lavas straddle the Low- to Medium-K boundary on a K₂O-SiO₂ plot, whereas Guguan II lavas are slightly more enriched and plot in the Medium-K field. Strong enrichments in K and other LIL elements observed for the Kasuga cross-chain farther north in the Mariana arc are absent. Olivine Fo decreases and plagioclase An increases towards the magmatic front. These relations suggest that water contents increase towards the magmatic front in the Guguan cross-chain. Spider diagrams for Guguan cross-chain lavas show the characteristic elemental enrichments of arc lavas, most notably LIL elements (Rb, Ba, Th, U, K, Pb, and Sr); similar but muted enrichments are found in basalts formed by seafloor spreading in the Mariana Trough (MTSB). Trace element variations observed across the Guguan cross-chain indicate that the fluid-dominated ‘Subduction Component’ diminishes away from the magmatic front and is replaced by a component that manifests either sediment melt or the MTSB mantle source. Ba/La vs. La/Yb systematics show that magmatic front lavas plot near the fluid-dominated endmember whereas Guguan II plots along the trends inferred for sediment melts. Similarly, Th/U doubles across the cross-chain, from ~1.5-2.0 along the magmatic front (consistent with U-rich fluids from altered oceanic crust, AOC) to ~2.5-3.0, similar to that of MTSB and approaching values for sediment melts. On a plot of Zr/Nb vs. Th/Nb, lavas from

along the magmatic front (esp. Guguan) show the high Zr/Nb expected for depleted mantle that is fluxed by hydrous fluids. W. Guguan and Guguan II show lower Zr/Nb and Th/Nb that trend towards sediment and MTSB. Surprisingly, there is little systematic variation in Sr/Nd and Pb/Ce across the chain. There is no systematic variation in Pb isotopic compositions across the arc. There is a marked gradient in $^{87}\text{Sr}/^{86}\text{Sr}$, decreasing from ~ 0.7035 along the magmatic front to 0.7032 for W. Guguan and 0.70317 for Guguan II. These values approach the mean of 0.70291 ± 0.00015 found for MTSB. $^{143}\text{Nd}/^{144}\text{Nd}$ also decreases slightly, but $^{176}\text{Hf}/^{177}\text{Hf}$ decreases slightly from the magmatic front to the rear. Coupled isotopic and trace element variations are difficult to reconcile with suggestions that cross-arc variations result from increasing participation of sediment melt with distance from the magmatic front.