Role of Subducted Basalt in the Genesis of Island-Arc Magmas: Evidence from Seafloor Lavas of the Western Aleutian Arc

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Results of the Western Aleutian Volcano Expedition and German-Russian KALMAR cruises include the discovery of seafloor volcanism at the Ingenstrem Depression and at unnamed seamounts 300 km west of Buldir, the westernmost emergent volcano in the Aleutian arc. The newly discovered features fall on a volcanic line connecting Buldir and other emergent volcanoes to Piip Seamount, which is located in the far western Aleutian Komandorsky area. These discoveries indicate that the surface expression of active Aleutian volcanism falls below sea level at 175°E, but is otherwise continuous for more than 2000 km of arc length from 163°W to 167°E longitude.

Many of the western Aleutian lavas are basalts, geochemically similar to basalts from elsewhere in Aleutians and other arcs (La/Yb 4-8, Sr/Y<30, $^{87}Sr/^{86}Sr$=0.7031-0.7033). The seafloor samples also include high-Sr lavas (>700 ppm Sr), which are mostly plagioclase-hornblende andesites and dacites with low Y and middle-heavy rare-earth elements, fractionated trace element patterns (Sr/Y=50-200, La/Yb=9-25) and MORB-like isotopes ($^{87}Sr/^{86}Sr < 0.7028$). The most Sr-rich lavas are magnesian rhyodacites (SiO_2~68%, Mg# >0.65) with Sr=1250-1700 ppm, Y=4-7 ppm, low abundances of all rare-earth elements (La<7 ppm, Yb<0.4 ppm) and $^{87}Sr/^{86}Sr < 0.70266$. MORB-like isotopes and strongly fractionated trace element patterns in the high-Sr lavas (low Ce/Pb, Ta/Th, Ta/Nd, high La/Yb, Gd/Yb, Sr/Y) are consistent with a source in subducted basalt and a melt residue that contained garnet and rutile. Recent liquid/eclogite partitioning results (Kessel et al., 2005 – Nature v. 437, p. 724) and similar fractionation of Ba/Th in the western Aleutian seafloor lavas (Ba/Th ~50-200) compared to MORB and seawater-altered MORB (Ba/Th ~50-100) indicate that this source component was a hydrous partial melt of subducted basalt.

Mixing relationships for Sr and Pb isotopes with key trace element ratios (La/Yb, Sr/Y, Ce/Pb) show that the subducted-basalt source component is present in lavas of some emergent volcanoes in the western Aleutians, but radiogenic Pb and Sr from subducted sediment renders this component invisible for these isotopes in most central and eastern Aleutian lavas. In contrast, lavas from all Aleutian locations display a continuum of compositions in plots of Hf-Nd isotopes against Ta/Th, Ta/Nd and Ta/Hf. Data patterns in these plots point toward an end-member that is isotopically like MORB, but has low Ta abundances compared to Th, Nd and Hf. This end-member is most clearly expressed in western Aleutian seafloor lavas. These patterns require three end-member mixing among source components derived from subducted sediment, the sub-arc mantle and subducted basalt. The same conclusions arise from mixing relationships in Hf-Nd Isotope space combined with the Nd/Hf. Mass balance calculations, which are subject to interpretations of elemental abundances in the end-members, indicate that much of the Th, Nd and Hf in Aleutian lavas are derived from subducted basalt. These results appear to rule out source models based on binary mixing between mantle and subducted sediment end-members for Th, Hf, Nd and other light rare-earth elements.