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Continental Style Calc-alkaline Plutonism in an Oceanic Island Arc: the Central Aleutian Hidden Bay Pluton

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Calc-alkaline plutons are major crustal building blocks of continental margins, but are rarely exposed in oceanic island arcs. One of the best studied calc-alkaline I-type plutons in an oceanic arc is the 34-30 Ma, ~10 km wide Hidden Bay pluton on Adak Island in the Aleutian arc (e.g., Citron et al. 1980; Kay et al. 1990). Although small compared to most continental plutons, similarities in intrusive units, mineralogy and chemistry suggest common formation processes. Extensive new radiometric dating along with trace element and isotopic analyses on a wide range of samples from the Hidden Bay Pluton enhance these comparisons. Existing and new Ar/Ar ages from 16 gabbro, porphyritic diorite, diorite, granodiorite, leucogranodiorite and aplite samples range from 34.6 to 30.9 Ma and indicate an ~ 4 Ma intrusion history. The age distribution is consistent with the pluton being emplaced in multiple episodes related to several centers that formed during the waning stages of volcanism as the magmatic arc front was displaced northward in response to an accelerated period of forearc subduction erosion. The Hidden Bay pluton, which intrudes the mafic volcanic and sedimentary rocks of the Eocene/Oligocene Finger Bay Formation, differs from continental plutons in having more oceanic like isotopic ($^{87}Sr/^{86}Sr$ = 0.703-0.7033; epsilon Nd = +9 to +7.8) and lower LIL ratios.

The mineralogical and compositional data on the gabbroic to leucogranodioritic units of the Hidden Bay pluton show they evolved in the lower to mid-crust with more silicic units rising buoyantly to higher levels where final crystallization and segregation of aplites occurred. Most of the exposed gabbro and all of the mafic diorite units are dominantly crystal cumulates, although several isotropic gabbros have whole rock compositions approximating those of the widespread post-late Miocene high Al basalts in the Aleutians. One difference is the lower Ba/La and Th/La ratios in the Hidden Bay pluton units that along with similar features in other pre-late Miocene central Aleutian magmas can be attributed to less partication of a subducted sediment component in their mantle source. The volumetrically dominant units in the pluton are silicic diorites and granodiorites (58-63% SiO_2) with leucogranodiorite (67-70% SiO_2) occurring in lesser amounts. The silicic units are considered to be deep-crustal differentiates of high-Al basalt with contamination by oceanic lithosphere and basement crust required to explain their less evolved Sr and Nd isotopic signaturese. Mafic dikes cutting the plutonic units are interpreted as representing the mantle-derived magmas gnerated as the arc front moved northward.

The formation of the calc-alkaline Hidden Bay pluton in the central Aleutian arc is best explained by a relatively thick oceanic island crust that could have been near the estimated modern day thickness of > 37 km, which is based on receiver function analyses (Janiszewski et al., 2013). Other contributing factors to calc-alkaline pluton formation include high fluid concentrations that can be explained by evolution in a relatively closed system magma chamber due just before the magmatic lull that corresponds with the northward stepping of the Aleutian arc after 30 Ma. A contractional stress environment contributed to the formation of pargasitic hornblende in the deep crust enhancing the calc-alkaline signature.

References:

[1] Kay et al [1990] Geol Soc Special Paper 241, 233-255.

[2] Citron, G. et al., 1980, Geology 8, 375-379.

[3] Janiszewski et al., 2013, Geochem Geophysics Geosys 14, 2977-

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