Different parental magmas for plutons versus lavas in the central Aleutian arc

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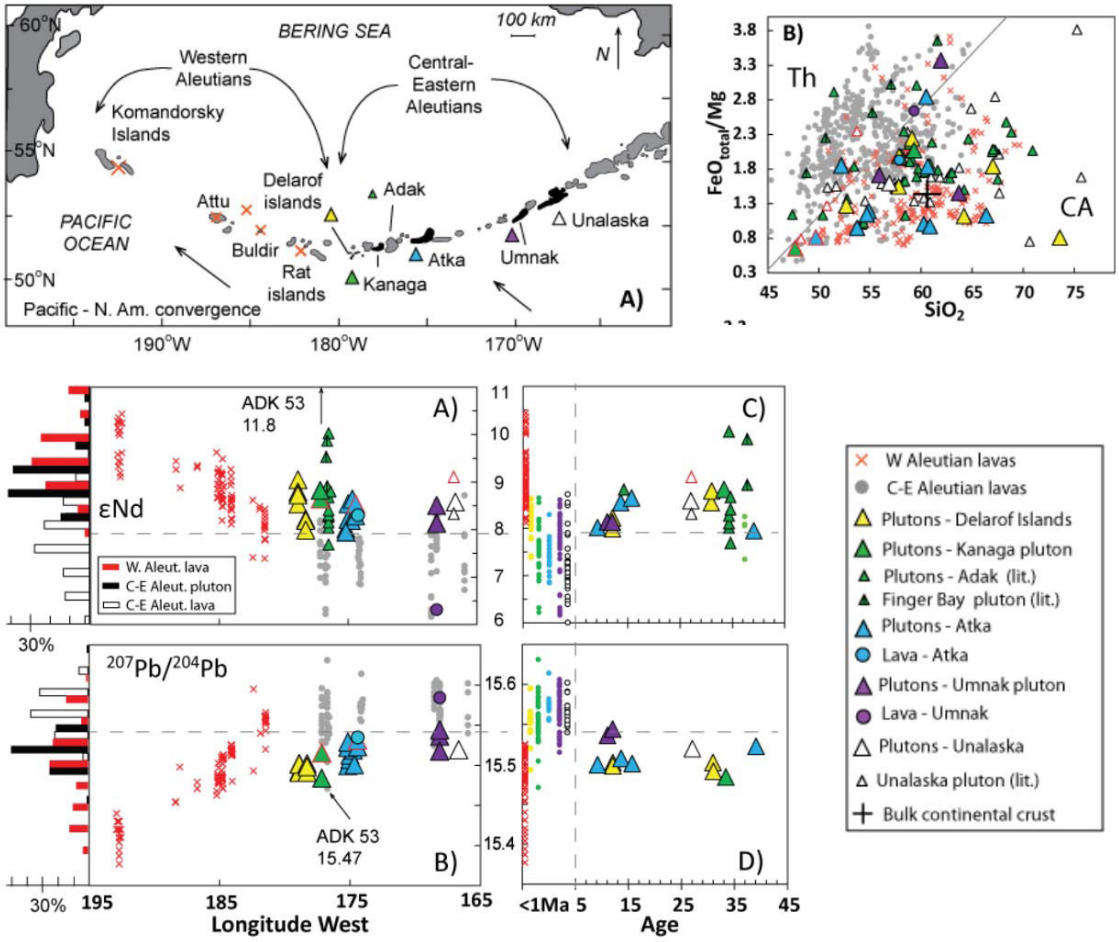
The oceanic, Aleutian magmatic arc has never been rifted, the crust is relatively thick compared with other Pacific arcs, the islands are relatively large, and thus the islands host extensive exposures of Eocene to Miocene plutons as well as Eocene to Holocene lavas. These large outcrops of plutonic rocks are unique among oceanic arcs worldwide, and offer an exceptional opportunity to study the mid-crust in such settings. Most geochemical work on the Aleutians has focused on Holocene lavas. With a pilot grant from NSF GeoPRISMS[1], we obtained samples of plutons from the Aleutians collected by the US Geological Survey from 1950 to 1980, and made modern trace element and isotope analyses of these samples. Prior to this, there were very few similar studies of Aleutian plutons. The results of our preliminary study are as follows.

Cenozoic plutons that comprise the middle crust of the central and eastern Aleutians have distinct isotopic and elemental compositions compared to Holocene tholeiitic lavas in the same region, including those from the same islands (Cai et al. 2013, 2014, 2015). Therefore the Holocene lavas are not representative of the net magmatic transfer from the mantle into the arc crust. Compared to the lavas, the Eocene to Miocene (9-39 Ma) intermediate to felsic plutonic rocks show higher SiO_2 at a given Mg/(Mg+Fe). In other words, the plutons are "calc-alkaline" whereas the lavas are dominantly tholeiitic. Crucially, the plutons also have higher εNd-εHf values and lower Pb and Sr isotope ratios than the lavas. In all of these ways, the plutonic rocks strongly resemble calc-alkaline, Holocene volcanics with "depleted" isotope ratios in the western Aleutians, whose composition has been attributed to significant contributions from partial melting of subducted basaltic oceanic crust. The new isotope data on the plutons data reflect temporal variation of central and eastern Aleutian magma source compositions, from predominantly calc-alkaline compositions with more "depleted" isotope ratios in the Paleogene, to tholeiitic compositions with more "enriched" isotopes more recently. Alternatively, the differences between central Aleutian plutonic and volcanic rocks may reflect different transport and emplacement processes for the magmas that form plutons versus lavas. Calc-alkaline parental magmas, with higher SiO_2 and high viscosity, are likely to form plutons after extensive mid-crustal degassing of initially high water contents. In any case, our isotope data have overarching importance because the plutonic rocks are chemically similar to bulk continental crust, whereas the central Aleutian lavas are not. Formation of similar plutonic rocks worldwide may play a key role in the genesis and evolution of continental crust.

During fieldwork in summer 2015, funded by a second GeoPRISMS grant[2], we will sample older volcanic rocks that are intruded by Paleogene plutons on Unalaska, Umnak and Atka Islands, ensuring that we have overlapping age coverage for volcanic and plutonic rocks in the central Aleutians. We can then test whether the isotopic and compositional differences between central Aleutian plutons and lavas reflect a temporal evolution in the arc, or the continuous presence of two distinct magma series throughout arc history.

We will also make detailed studies of some of the larger plutons in the Aleutians, including the Shaler pluton on Unalaska Island. There are fewer than five published analyses of the Shaler pluton, which is the largest exposed pluton in the arc. Prior to our pilot work there was only a single, imprecise, biotite $^{40}Ar/^{39}Ar$ age on the pluton from the Shaler.



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[1]Research reported here was funded by NSF OCE-1144759: "Collaborative Research: Plutons as ingredients for continental crust: Pilot study of the difference between intermediate plutons and lavas in the intra-oceanic Aleutian arc", Peter Kelemen, PI, Steve Goldstein, Sidney Hemming, M. Rioux(UCSB) co-PI's, $150,000, 2011-2014.

[2]Ongoing field work in the is funded by NSF EAR-1457293: "Collaborative Research: Focused Study of Aleutian Plutons and their Host Rocks: Understanding the building blocks of continental crust",P. Kelemen lead PI, $200,000, 2015-17