Toward a Synoptic View of Alaska-Aleutian Volcanic Rock Geochemistry: The Rationale for a Campaign of Isotope Data Acquisition on Existing Samples

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Introduction

The Alaska-Aleutian arc (Fig. 1) provides a prime opportunity to understand how the magmatic output of a subduction system responds to variations in the physical parameters of subduction. The region though, is immense and remote, and so presents a daunting challenge to investigators whose aim is to develop a synoptic view of the system as an approach to moving forward on key scientific issues. For those of us in petrology-geochemistry-volcanology, it is therefore fortunate that so much fieldwork has already been done, and that so many high-quality geochemical analyses have already been acquired. The point of this white paper is therefore to summarize the existing data sets that are relevant to the use of volcanic rock geochemistry to understand subduction systems, and to highlight some recent work as one approach to moving forward by first by taking advantage of work that has already been done.

Existing Sample Collections and Data

Large collections of Quaternary-age Aleutian lavas exist at several universities (e.g., Columbia, Cornell, Johns Hopkins, Wisconsin, Wyoming). Geochemical data from more than 2000 samples from these sources have been published and/or compiled and made available through review studies (Kelemen et al., 2003) and online databases. These data were generated over decades in many different laboratories and by diverse methods. A much larger, more geographically extensive sample set and more complete geochemical database is held by the Alaska Volcano Observatory (AVO). This database includes approximately 3600 fully modern XRF and ICPMS whole-rock analyses from a single laboratory (Washington State University). The largest part of this collection is from volcanoes along the Alaska Peninsula and in southern Alaska. This is important because it means that the AVO collection and related data are largely complementary to the above-mentioned university collections, which are primarily from the Aleutians.

In addition to the 5000+ samples mentioned above, which were collected entirely from on-land sites, there is now a complimentary sample set, which has been collected by dredging of seafloor volcanoes in the Aleutians. These samples were collected beginning in the late 1980's by the Russian *R/V Vulkanolog* (Yogodzinski et al., 1994), and more recently during the 2005 Western Aleutian Volcano Expedition on the *R/V Thompson* (White et al., 2007; Wyatt et al., 2007; Yogodzinski et al., 2007) and during two cruises of the German *R/V Sonne* as part of the German-Russian KALMAR project (http://kalmar.ifm-geomar.de). Most of the mapping and related dredging on these cruises has been focused in the western Aleutians, from Buldir to Piip Seamount, but seafloor volcanoes located throughout much of the Aleutian system, from Buldir to Unalaska, have now also been sampled (Fig 1).

Despite the widespread availability of samples and decades of study, there are still relatively few places where fully complete and modern geochemical data sets are available. The main shortfall is in the area of isotopic data. In the Aleutian part of the system, the availability of isotopic data is relatively good. For example, a database of 2000 samples includes approximately 260 Pb, Sr and Nd isotope measurements, published over many years, from widely scattered locations along the arc. These data, combined with unpublished data from active studies of mostly seafloor lavas, provide a clear view of systematic changes in the geochemistry of Aleutian lavas over the full length of the arc (Fig. 2). Further east, for volcanoes along the Alaska Peninsula and in southern Alaska, the availability of isotopic data is poor and insufficient to provide anything beyond the most basic conclusions about geochemical variability in the continental part of the Alaska-Aleutian system. In addition, data for the Lu-Hf isotopic systems and modern measurements of oxygen isotopes on mineral separates are only available in small numbers from very few places anywhere in the Alaska-Aleutian system.

More Isotopes

With the samples and data described above, it is easy to imagine a campaign of isotope data acquisition designed to test ideas about the geochemical products of subduction, and their relationship to the creation of continental crust. In particular, new isotopic data for volcanoes on the Alaska Peninsula and in southern Alaska will provide a basis for detailed comparison between the continental and oceanic parts of the Alaska-Aleutian arc. It is interesting that despite broad differences in crustal thickness of the over-riding plate and parameters such as arc-trench gap (width of the outer arc), existing data suggest that there are not large-scale isotopic differences between the oceanic and continental parts of the system (George et al., 2004). It is very likely though, that acquisition of a large quantity of high-quality isotopic data over the whole Alaska part of the arc (for Pb, Sr, Nd and Hf), combined with existing major and trace element data, will reveal systematic differences from the Aleutian part of the arc that will be interpretable in the context of key questions about subduction magma genesis.

For example, the presence of abundant seamounts in the Gulf of Alaska and in front of the Alaska portion of the arc (Fig. 3) provides a basis for hypothesizing that certain aspects of OIB geochemistry might be transferred to arc magmas in southern Alaska but not in the Aleutians. An approach to identifying a subducted OIB end-member could be based on recent results from dredging and geochemical studies, which have highlighted the presence of a high-Sr geochemical source end-member in seafloor volcanoes in the western Aleutians. This end-member has some characteristics of a MORB fluid (Class et al., 2000; Miller et al., 1994), and although the details of its origin remain uncertain, it seems clear that its source must be predominantly in subducted basalt (Fig. 4). This is important, because it provides a basis for quantifying the role of subducted basalt in controlling the geochemistry of arc lavas from other parts of the Aleutians and other arc systems worldwide. If subducted seamounts are contributing to the source of arc magmas in southern Alaska, we might expect the geochemical character of OIB to be expressed in the form of a high-Sr end-member with elevated $^{206}Pb/^{204}Pb$ (Keller et al., 1997) and possibly low ε_{Hf} relative to ε_{Nd} (Yogodzinski et al., 2010). This is one way that by developing a synoptic view of Alaska-Aleutian volcanic rock geochemistry, we can provide an improved basis on which mass flux through subduction systems may be quantified and related to the genesis of continental crust.

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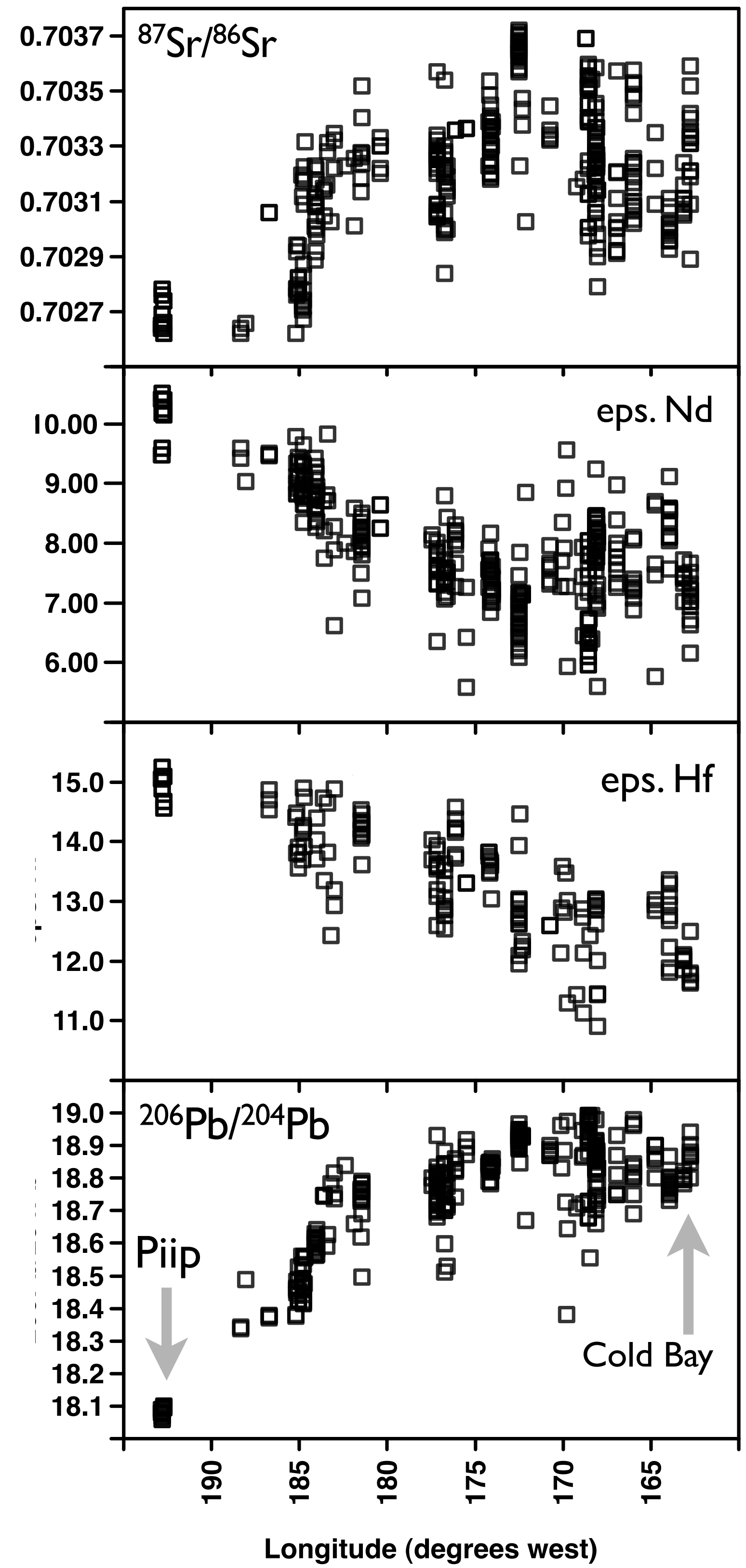

Fig. 2 Along-arc isotopic variability for Quaternary Aleutian lavas.

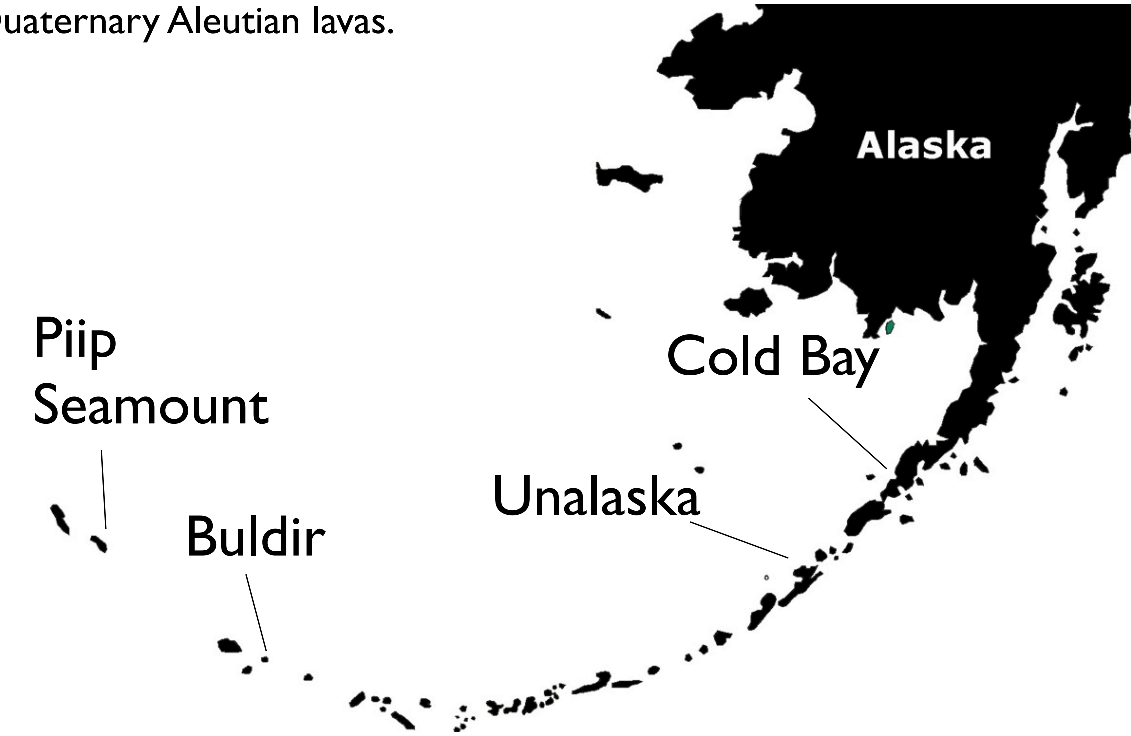

Fig. 1 Map of Alaska-Aleutian subduction system

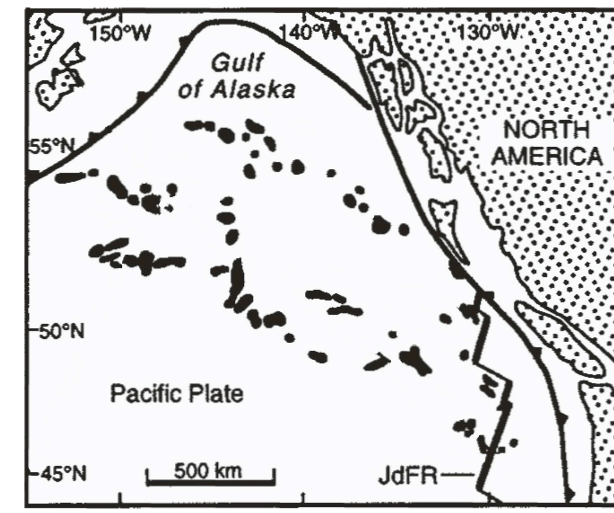

Fig. 4 Map of northeast Pacific seamounts and Gulf of Alaska, from Keller et al., (1997)

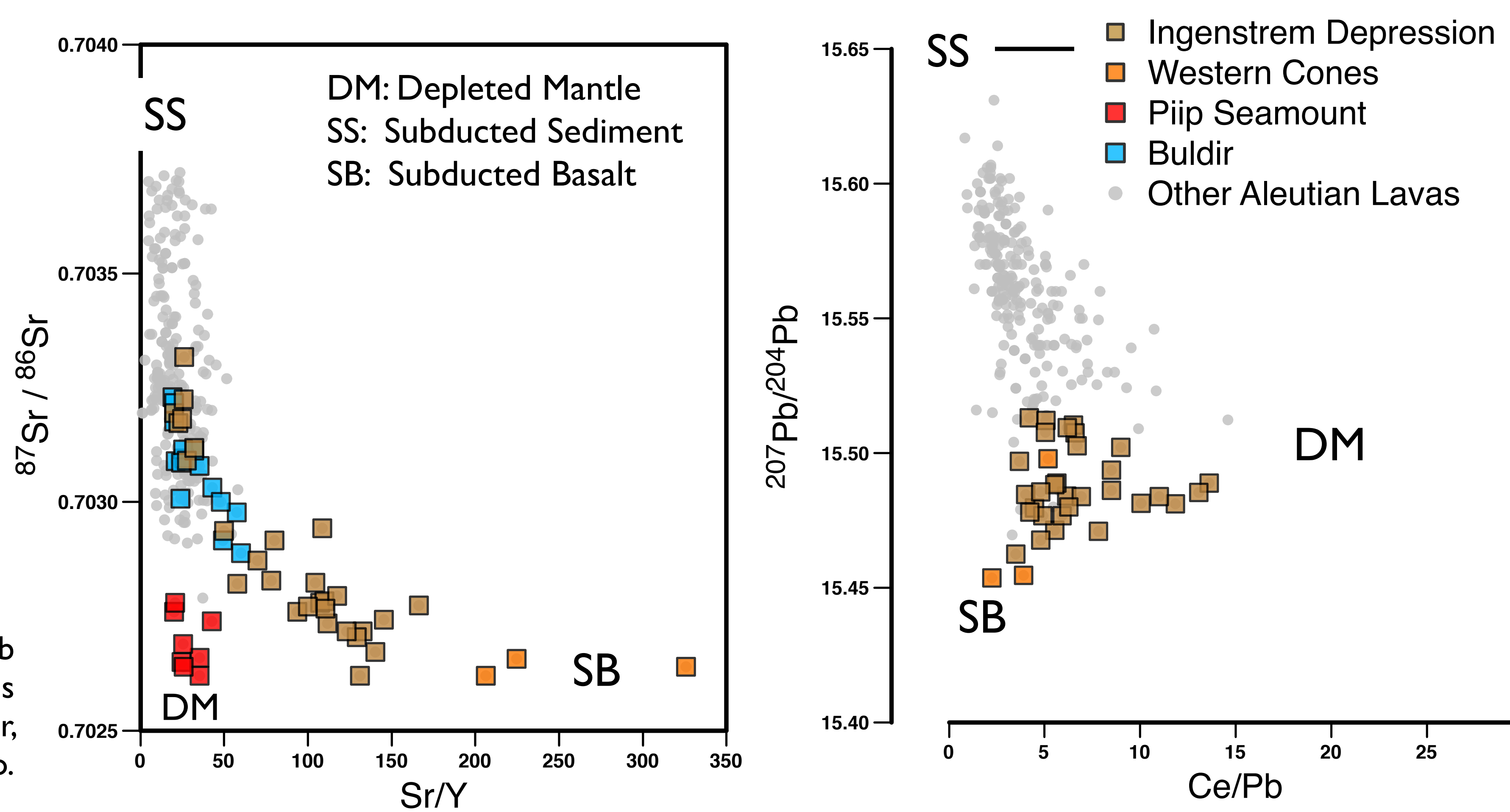

Fig. 4 Sr isotopes vs Sr/Y and Pb isotopes vs Ce/Pb adopted from Miller et al., (1994). Colored symbols are lavas from western Aleutian seamounts and Buldir, the westernmost emergent volcano.