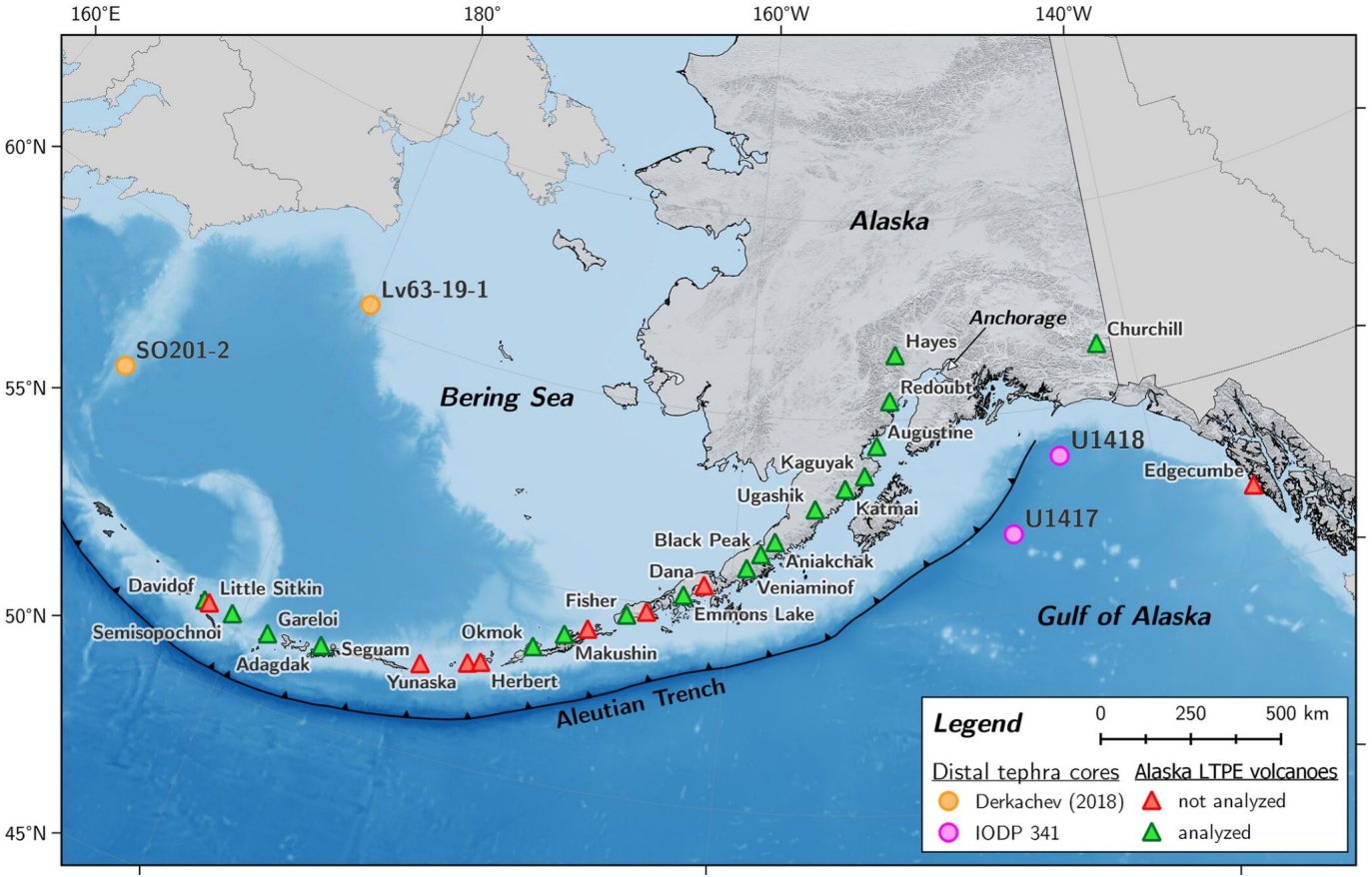
Magma Diversity Along and Across the Aleutians



Lubbers et al. (2023) G3

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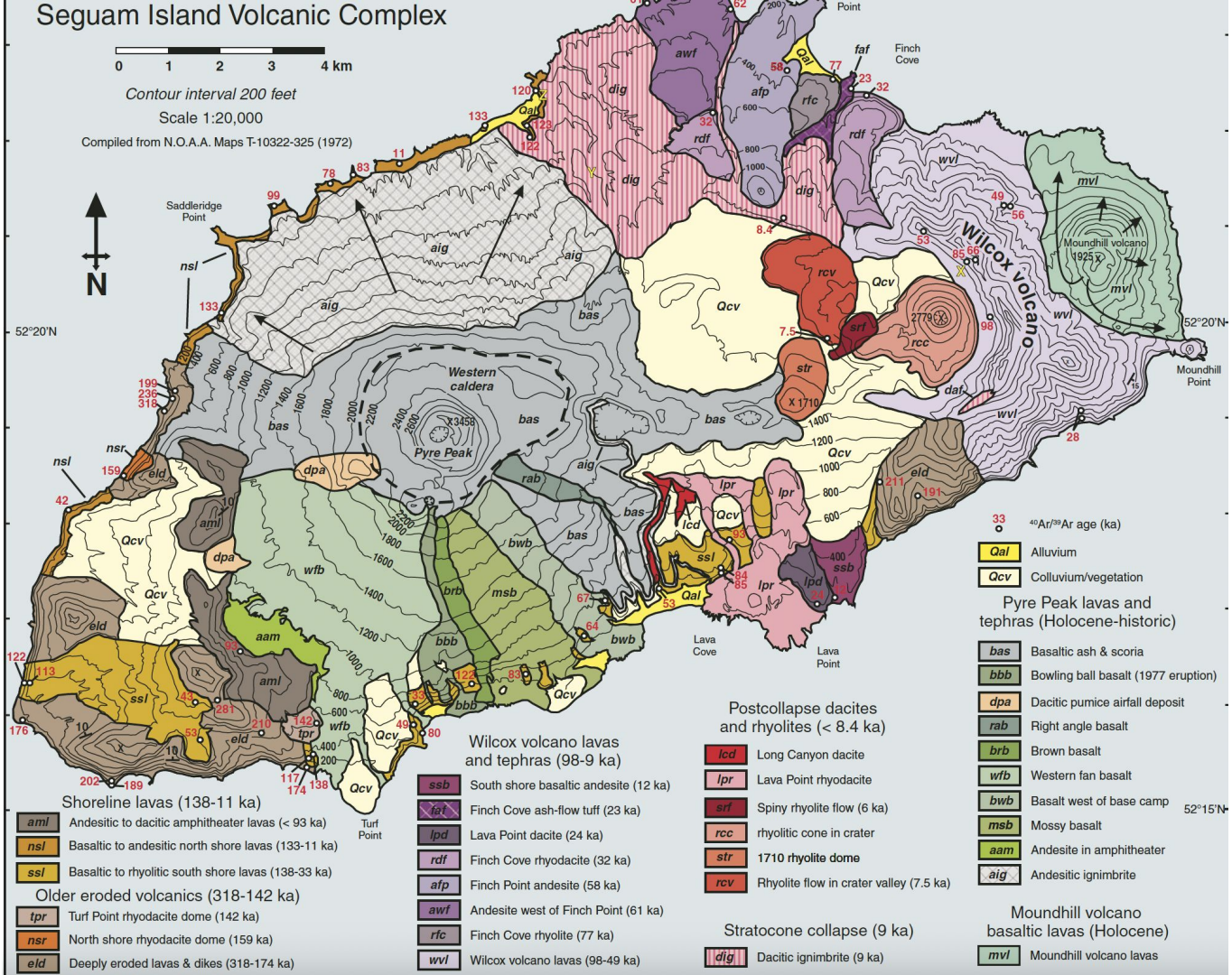
Not pictured (but awesome members of our team!):

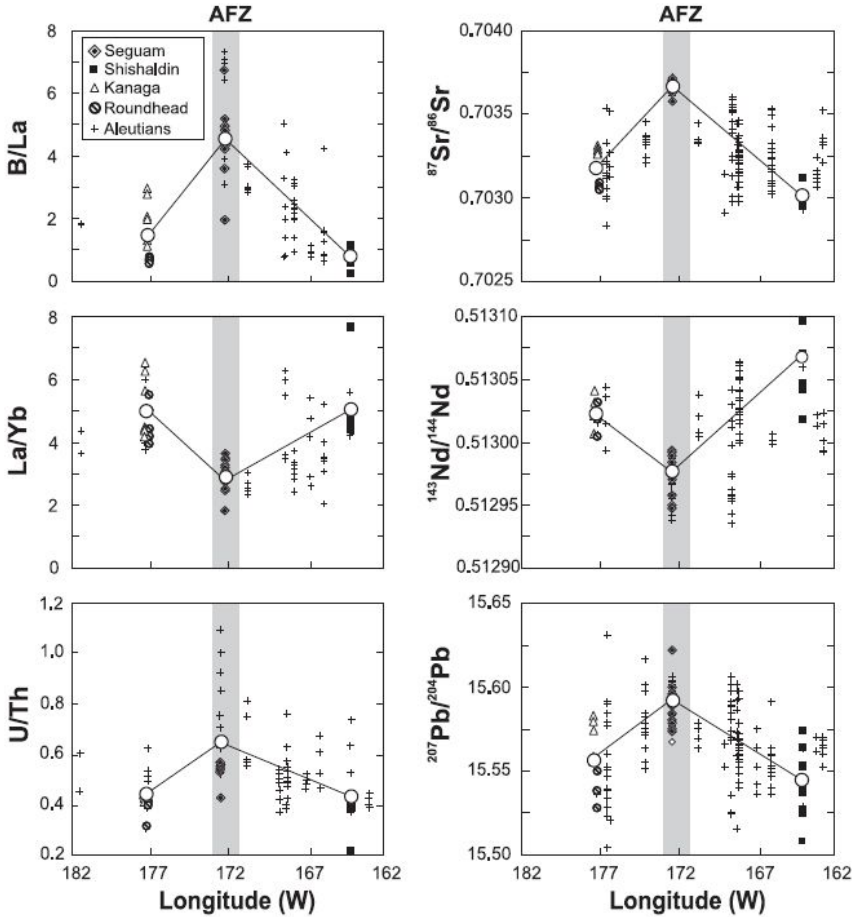
- Sloane Kennedy (Oregon State
- Alex Hammerstrom (WHOI)
- Bennet van Horn (Oregon State)
- Brennan Williams-Mieding (Boise)
- Adriana Pina



Jicha & Singer 2006

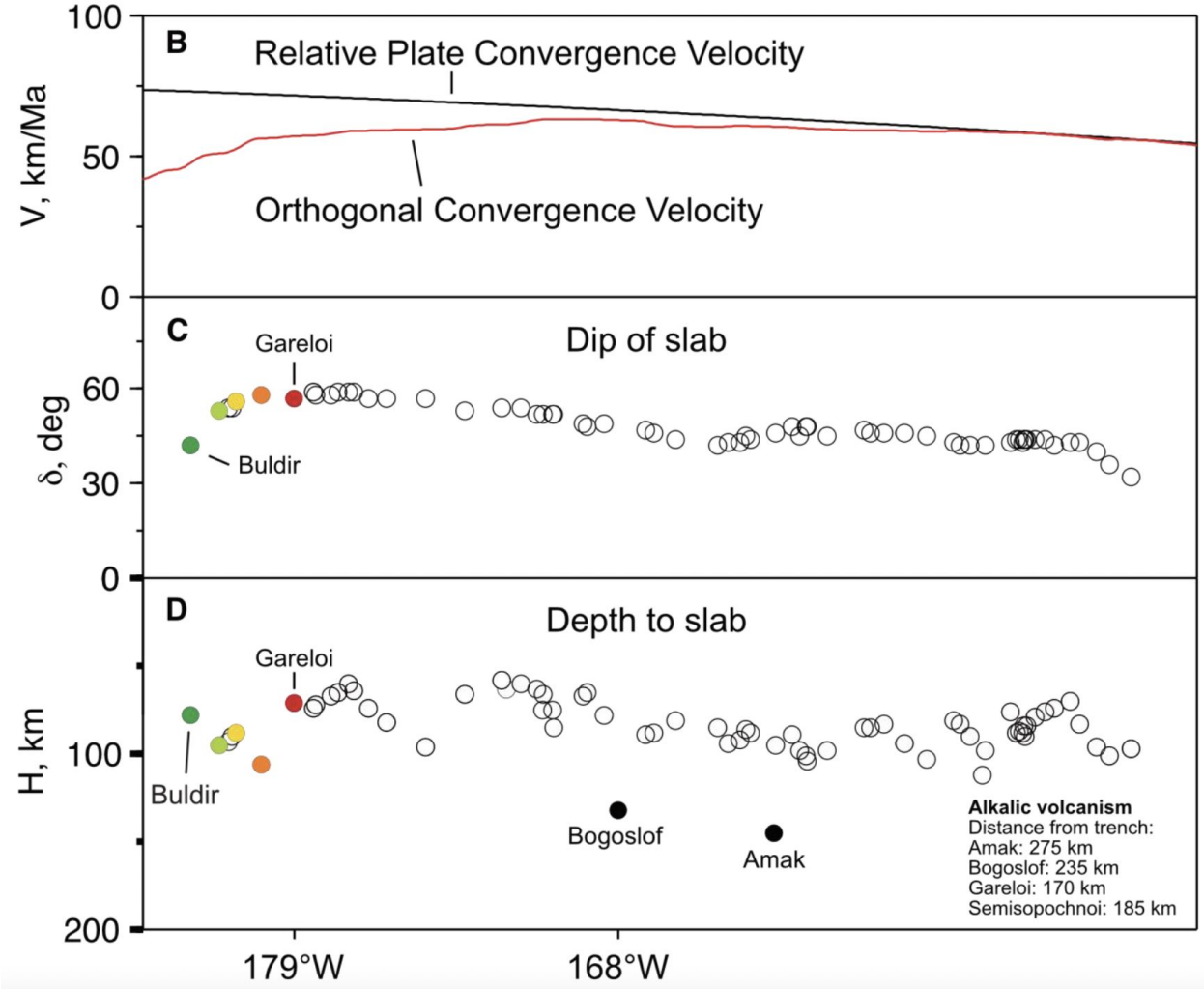
The state of arc diversity

- Is a given sample representative of a volcano's geochemical diversity?
- How do we ensure you are getting representative sampling from each volcano as you make comparisons?
- *What about plutons??*
- Whole rocks are well represented in AVO databases, particular majors and traces
  - Isotopes are limited outside well studied segments e.g., Central Aleutians
  - Glass measurements are difficult to perform (microlitic) and locationally spotty
  - Mineral scale analyses are inconsistently available



Jicha et al (2004) JPet

Zooming out: The Role of Tectonics



Oxhorn (2022), Master Thesis (UGA)

Proposed work packages

- We plan to constrain **a single line of descent from source to surface**. This requires we develop a good picture of which targets to analyze.
  - What role does fractionation ACTUALLY play in the origin of Aleutian volcano diversity?
  - Does polybaric fractionation actually occur at these systems?
  - How do these volcano-scale processes vary across the arc?
  - How is arc-wide variability a function of tectonic controls?

- We hypothesize we will see magmatic diversity corresponding to different tectonic features like (1) crust-slab interface (2) ocean vs. continent inputs (3) Moho depth, (4) 3D asthenosphere flow dynamics, (5) variations in upper plate thickness
  - We aim to quantify how composition relates to specific parameters like convergence rate, sediment inputs, crustal structure
  - We plan to relate these features to new measure of along-arc differences

Data Needed to Broadly Address Questions

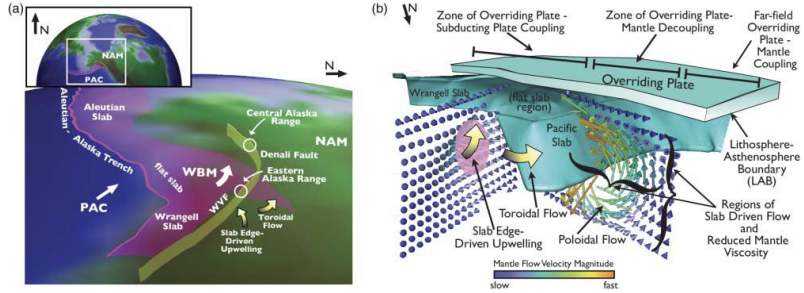
1. Major Elements
2. Trace Elements
3. Isotopes
4. Tectonic parameters
5. Interface with geodynamic models

Three modes to consider for each data type: whole rock, glasses (groundmass vs. inclusion), mineral phases

<u>Preparation for Data Collection</u>

- Break out arc into “segments of study”
- Identify samples with a lot of material at the GMC (e.g. Katmai, Shishaldin) that can be parsed between labs to study multiple aspects

Preliminary focus groups



We are dividing focus into different streams

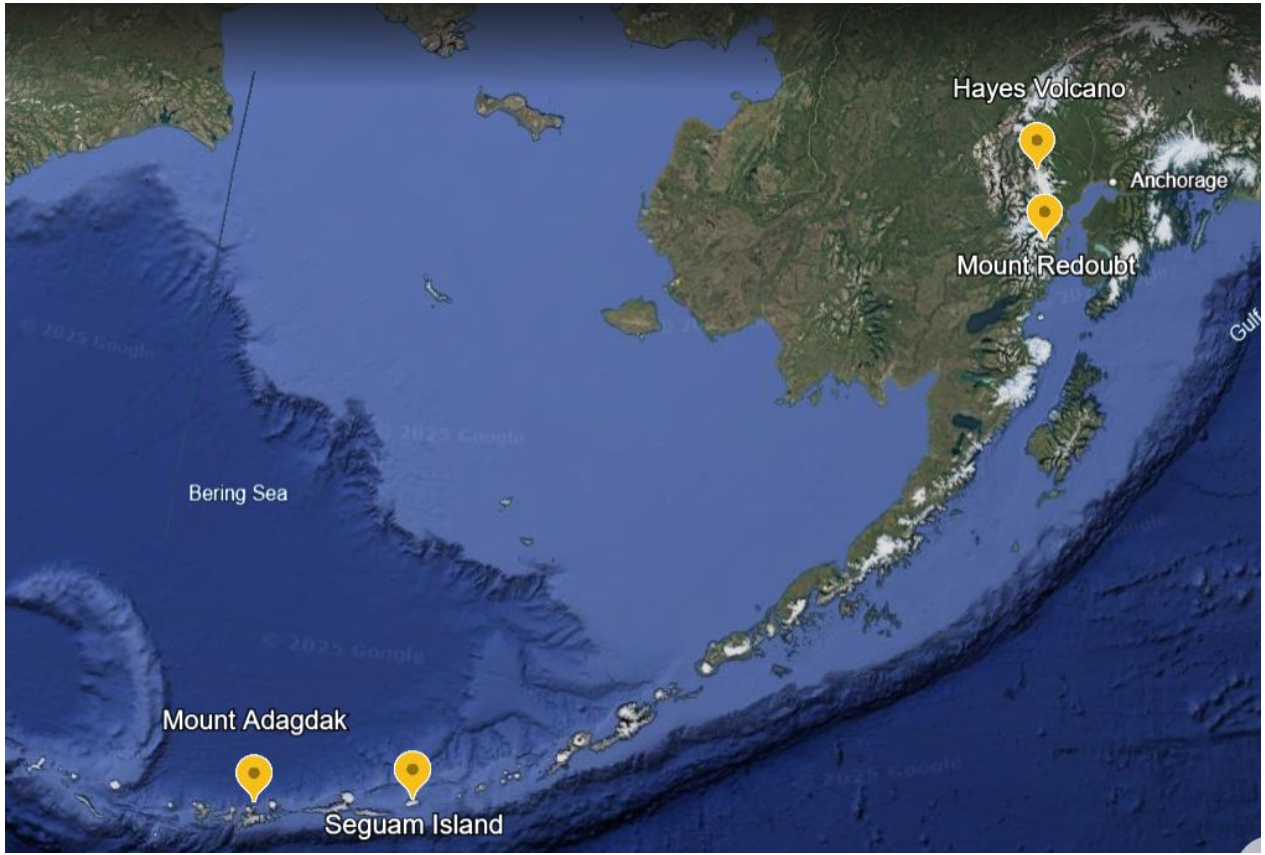
- Structure (e.g., upwelling in the East)
  - Tectonic framework
  - Slab models e.g., Slab 2.0
  - Geodynamic models e.g., Jadamec et al. 2024
  - Thermal models (TBD)
- Source (isotopes, trace elements → mantle vs. crustal sources, parental melt compositions, mantle source lithology)
- Evolution (traces, majors | whole rock, minerals, glass → origin & diversity of andesites)

But where to focus?

Our focal volcanoes needs to fit a few criteria:

- Crustal thickness is a fundamental control on magmatic diversity in Cook Inlet but not the Aleutians
- Fractional crystallization will be visible as a control on magmatic diversity where we can construct polymeric liquid line of descent
    - Validate magmatic architecture with seismic reflection
- Primary magmatic compositions vary based on crustal, slab inputs
- Models of tectonic control, slab properties, and magma conditions
- There should be geochemical variation corresponding to different episodes as edifice evolves

Volcanoes of Interest



Four selected systems:

East: Hayes and Redoubt (potentially Spurr)

West: Seguam and Adagdak

Volcanoes selected based on location, known compositional diversity, slab dynamics, sample availability, and overlap with Gas and Geochron Group goals

State of the working group today:

- Mattia has been hard at work building a GeoPrisms data summary product (see next slide)
- AVO curating an expert-dataset including glass chemistry (1)
- Bennet Van Horn continuing PhD isotope measurements
- Margaret and Nick building out combined geochemical-tectonic database framework
- Setting up 2026 plans (hopefully an NSF proposal!)

- Join our Discord!!

V51E-0085 The Aleutian-Alaskan System: Revisiting the Correlations between Magma Geochemistry and Tectonic Parameters along the Northern Arc of the Ring of Fire

Mattia Pistone [1], Nicholas Barber [2], Susanne Straub [3], Alexander Hammerstrom [4], Margarete Jadamec [5], Nathan Graham [6], Bennett Van Horn [7], Brennan Williams-Mieding [8], Natali Kragh [9], Sloane Kennedy [7], Samuel Oxhorn [10], Elizabeth Grant [11]

1 GEORGIA 1785 · 2 · 3 COLUMBIA UNIVERSITY · 4 · 5 · 6 UAF UNIVERSITY OF ALASKA FAIRBANKS · 7 Oregon State University · 8 BOISE STATE UNIVERSITY · 9 MONTANA STATE UNIVERSITY · 10 OCEANAGOLD · 11

Collaborative Project Goal

What causes the geochemical diversity along global volcanic arcs? To answer this question, we focus on the Aleutian-Alaska arc, which is one of the longest single arc-trench volcanic systems in the world. Following the NSF-sponsored Alaska-Aleutian Arc Workshop, we are currently reviewing the existing Alaska Volcano Observatory Geochemical Database reporting ~9,000 bulk rock major and trace element data. We aim to identify existing geochemical gaps and illuminate both source contributions driving primary Aleutian arc magma genesis and crustal differentiation processes along the arc.

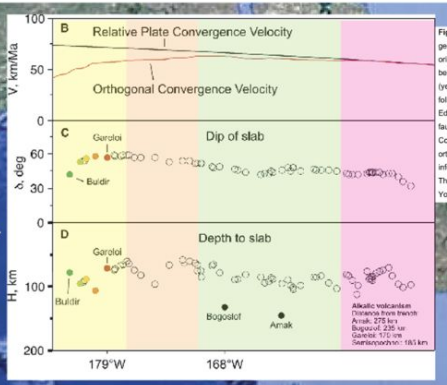


Figure 1: A) The Aleutian-Alaska arc is ~4000 km long. Based on arc geometry, the relative obliquity between plate convergence and trench orientation, and the inferred dip and depth of the subducting slab beneath each volcanic center, four sectors can be identified: western (yellow), central (orange), eastern (green), and continental (pink). The following volcanic centres are excluded here: Wrangell, Mt Churchill, Edgecumbe, Buzzard Creek, St Paul, and St Michael. Rose diagrams of faults and joints distribution inferred from topographic evidence are from Coats (2004). B) The relative plate convergence velocity (km/Ma) and orthogonal convergence velocity (km/Ma) along-strike of the arc. C) The inferred dip (δ) of the subducted slab at each Aleutian volcanic center. D) The inferred depth (H) to the slab for each Aleutian volcanic center. After Yogodzinski et al. (2015) and Oxhorn (2022).

Acknowledgments

Funding support for new bulk rock data from Western Aleutians (research thesis by S. Oxhorn, Magma Mia Lab, University of Georgia) (SNF Ambizione Fellowship PZ00P2_168166):

Funding support for NSF-sponsored GeoPRISMS Leg 3 expedition to the Western Aleutians in September 2015:

Access to rock samples: Smithsonian

Access to AVO Geochemical Database:

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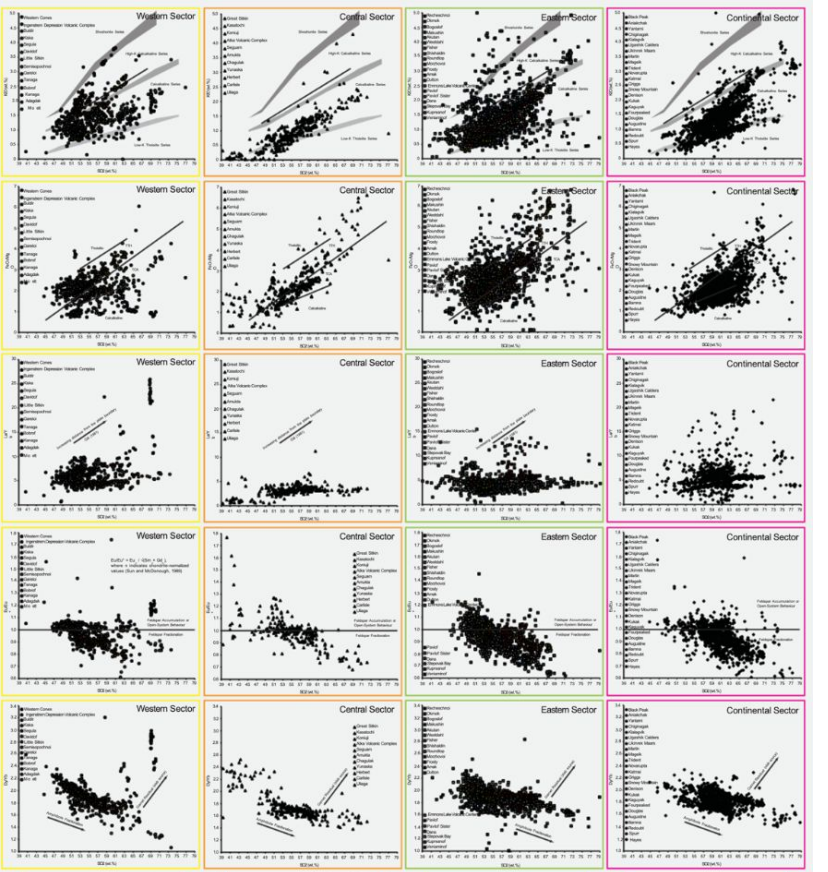

Figure 2: Reprentative geochemical plots reporting all published bulk rock composition data (~9,000 bulk rock major and trace element data) from the Alaska Volcano Observatory Geochemical Database. K2O vs. SiO2 plot shows lines and labels after Le Maitre et al. (1989) and Rickwood (1989) with shaded fields from Rollinson & Pease (2021), and references therein. FeOt/MgO vs. SiO2 plots shows fields delineating tholeiitic, calc-alkaline, transitional-tholeiitic (TTH), and transitional-calc-alkaline (TCA) trends following Miyashiro (1974), Kay & Kay (1994), and Arculus (2003).