Ongoing GeoPrisms Aleutian Volcano Research

Cleveland Volcano, Islands of Four Mountains, Alaska.
*Photo: Anna Barth*

With Contributions From:
- Daniel Rasmussen (LDEO)
- Diana Roman (DTM-Carnegie)
- John Power & Matt Haney (USGS, AVO)
- Elizabeth Cottrell (Smithsonian)

“Slab to the Surface”

Terry Plank, Lamont Doherty Earth Observatory of Columbia University
Alaska Amphibious Community Seismic Experiment (AACSE)

2015-2106 GeoPrisms Field Programs
Eastern Aleutians: Depth to the Slab Varies Smoothly Along Strike

- **Last Erupted this year**
- **1200**
- **9990’**
- **9800’**

White lines are slab contours.

- **Globally Shallow!**

**Depth to slab**

<table>
<thead>
<tr>
<th>Depth (km)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Se</td>
</tr>
<tr>
<td>7</td>
<td>Amkt, Yu</td>
</tr>
<tr>
<td>8</td>
<td>Se, V, Vs, Ok, Mak, Aku, Wd, Fi, Sh</td>
</tr>
<tr>
<td>10</td>
<td>From Syracuse &amp; Abers (2006) G3</td>
</tr>
</tbody>
</table>

**From Syracuse & Abers (2006) G3**

Blue circles = historically active volcanoes.

**From Syracuse & Abers (2006) G3**
2016 Team on the Maritime Maid with the Maritime Helicopter (Initial Deployments were in 2015)
Objectives

• Where do Magmas Stall Prior to Eruption?
• Role of Primary Magma Composition?
• Relation to Eruption/Unrest?
Three Nuggets:

1. The Run-Up to Eruption: Shishaldin 1999

2. The Depth of Magma Stalling: Cleveland 2015/6

3. Connecting the Volcano to the Slab
1. The Run-Up to Eruption: Shishaldin 1999

**Fo** = forsterite composition of olivine = Mg/(Mg+Fe)

**Mixing Event:** Recharge Magma Drives Crystal to Increase in Fo

Crystal Resides, Then Erupts

Shape of Profile Reflects Mixing-to-Eruption Timescale

This Olivine Crystal Erupted 22 days After a Recharge Event
1. The Run-Up to Eruption: Shishaldin 1999

Seismicity

Crystal Depths (MI)

Crystal Depths Relate to Magma Recharge Over 9 Months of Run-up

Olivine Clocks

Rasmussen, Roman, Hauri, Plank, Bodnar, Power – EPSL in Press
2. The Depth of Magma Stalling: Cleveland 2015/6

**Back-Projection of Long Period Event**
3 hours before April 2016 Explosion
Shallower Depth of 2.5 km BSL

**VT Earthquakes Cluster at 5-7 km Beneath Cleveland Volcano**

**Seismicity at IFM over GeoP Deployment (Aug 15 – Aug 16)**

**GeoP Deployment w/infrasound**

**Permanent AVO**

**Aug 2015 Swarm**

**Spr 2016 Eruptions**

**Depth (km BSL)**

-15 -10 -5 0 5 10

**Depth BSL (km)**

-170 -169.95 -169.9 0 15 20

**Longitude (deg)**

**Normalized Stack Power**

-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

**Courtesy of Matt Haney**

**Courtesy of John Power**
2. The Depth of Magma Stalling: Cleveland 2015/6

Re-homogenizing the Melt Inclusion: Accurate Pressure of Entrapment

Using Melt Inclusions to Define Depth (P) of Magma Degassing

see Werner et al. (2017) JVGR
3. Connecting the Volcano to the Slab

**Slab T Proxy**

**H$_2$O/K$_2$O (wt%)**

*meltdown inclusion averages for each volcano*

**Mantle-Melting Pressure Proxy**

**Volcano Volumes!**

- Cleveland: 17 km$^3$
- Westdahl: 217 km$^3$

Plank et al. (2017) IAVCEI
3. Connecting the Volcano to the Slab

![Diagram showing the connection between the volcano and the slab.]

Systematic change in S-P time
Most Reasonably due to
Decrease in EQ Depth to the West
Leg 3 Western Aleutians:
The role of oxygen fugacity in calc-alkaline differentiation &
the creation of continental crust at the Aleutian arc

Project Leads:
Katie Kelley &
Liz Cottrell

- > 2,700 lbs of **rock** send to AVO, URI, & Smithsonian
- **tephra** from 8 volcanic islands (1st from Buldir, Segula, & Kiska)
- **gas** and spring samples @ Kiska, Gareloi, Kanaga; @ L. Sitkin, Tanaga
- 100% maintenance success at **30 seismic installations**
- new methods for assessment of hydrous melt inclusion **redox** at high flux synchrotron facilities (Cottrell et al., in revision)

(see T23I-03: New constraints on subduction inputs and volatile outputs along the Aleutian Arc. Lopez et al.)
Alaska Amphibious Community
Seismic Experiment

Diana Roman, Carnegie
Graduate student Janine Andrys operates the new rapid-quench HMC cold-seal apparatus at NMNH. Credit: Cottrell

- Experimental program to investigate calc-alkaline differentiation
- Conference: Experimental Studies of Subduction Zone Processes: Washington University in St. Louis, Missouri, June, 2018
Shallower coupling depth? and ~ vertical transport from slab?

Hi H₂O/K₂O cooler slab fluid

Lo H₂O/K₂O hotter slab fluid

Courtesy of Peter van Keken
Why is Depth to Slab so Shallow in this Sector of the Arc?

Trench Sediment Thickness after Ryan et al. (2011); Locked vs creeping (Freymueller, pers. comm).

But also...Upper Plate (end of shelf)