Voluminous eruption from a zoned magma body after an increase in supply rate at Axial Seamount

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What have we learned?

1. Axial Seamount: ideal natural laboratory to link magma reservoir and eruption dynamics. The magma reservoir is well imaged using seismic data and the volcano is monitored by instruments on the OOI. Understanding such linkages will be applicable to more hazardous on-land volcanoes.

2. Axial Seamount eruptions increased in volume, frequency, and temperature of lavas from 1998 and 2011 to 2015, consistent with a rapid increase in magma supply since 2011. Elevated supply continues today.

3. Variations in lava chemistry mimic variations in the underlying zoned magma chamber. First clear link for any volcano between an imaged magma chamber and compositions of erupted lavas.

4. Axial Seamount and other submarine volcanoes may erupt in previously undocumented explosive styles that might prove hazardous themselves.
a) Diagram showing the 2015 dike and the 2011 dike. The 2015 dike is marked with a red solid line, and the 2011 dike is marked with an orange dashed line.

b) Diagram showing the northward propagation of the 2015 dike and the southward propagation of the 2011 dike.

Right side of the image: Map showing the distribution of MgO (wt%) and depth (m). The map is color-coded to indicate the depth with the following ranges:
- 7.10-7.40
- 7.41-7.70
- 7.71-8.00
- 8.01-8.36

The map also shows the depth in meters with the following color ranges:
- 4800 m
- 4600 m
- 4400 m
- 4200 m
- 4000 m
- 3800 m
- 3600 m
- 3400 m
- 3200 m
- 3000 m
- 2800 m
- 2600 m
- 2400 m
- 2200 m
- 2000 m
- 1800 m
- 1600 m
- 1400 m
- 1200 m
- 1000 m
- 800 m
- 600 m
- 400 m
- 200 m
- 100 m
- 0 m

The map also includes markers for CASM and AX-101.
Inflation-predictable behavior and co-eruption deformation at Axial Seamount

Science

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Key Points

• We were able to forecast the 2015 eruption based on the patterns of surface deformation.
• A rapid increase in magma supply rate occurred after the 2011 eruption.
• A nearly vertical magma conduit accommodated increased magma accumulation before the eruption and was the source of magma for the eruption.
• Cabled tilt-meter data allowed us to observe a short episode of southward dike propagation before heading north for the rest of the episode.
Eruption forecast and magma supply

Long-term inflation/deflation record in Axial caldera

Inflation threshold at or above which eruptions are triggered

Change in seafloor elevation (meters)

1998 eruption

Data gap

Linear inflation @ 15 cm/yr

2011 eruption

Inflation @ 60 cm/yr

2015 eruption

~50 cm/yr

Pressure Measurements
288 Million m$^3$ magma removed from the magma chamber

1.95 times the volume of lava erupted in 2015

This implies that 140 Million m$^3$ of magma was in the dike
Dike propagation to the south
Seismic Constraints on Caldera Dynamics from the 2015 Axial Seamount Eruption

*Science*

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Seismic Analysis of 2015 Eruption

> We were able to track the seafloor eruption in unprecedented detail.
> We discovered an outward sloping ring fault beneath the caldera.
> The cabled network is allowing continuous observations from this eruption to the next.
Installing the Seismic Network
Earthquakes and Lava Explosions
Outward-sloping Ring Fault

- Magma chamber
- Dikes
- Lava flows
- Pre-eruption
- Syn-eruption

Depth, km

Distance, km

Magma Chamber

$M_w = 0$

$M_w = 1$

$M_w = 2$

$M_w = 3$
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