Bathymetric Analysis of Axial Seamount, Juan de Fuca Ridge

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Abstract:

Multibeam sonar data of active undersea volcano Axial Seamount were obtained by the University of Washington and processed using the CARIS HIPS & SIPS 7.1 software. Axial Seamount is currently being instrumented as a Regional Scale Nodes (RSN) Cabled Observatory of the NSF Ocean Observatory Initiative, led by the University of Washington. Seismic tomography has detected a significant magma reservoir beneath Axial's summit caldera, leading to the belief that sufficient activity in this region is forthcoming. The bathymetry of the region has been analyzed to delineate the geological implications of and processes associated with underwater volcanism. Research associated with this region will provide a better understanding of how undersea volcanoes can support biological communities, and the effects of magmatic activity on the surrounding terrain and biosphere.

Background:

Axial Seamount is an active submarine volcano located ~250 miles off the Oregon coast on the Juan de Fuca spreading ridge, and rises roughly 800 m above the rest of the ridge. The shallowest point of the summit is ~1400 m, and the caldera floor is roughly 1650 m deep. The most recent eruption occurred in April 2011. The presence of a caldera indicates previous eruptions, followed by the collapse of overlying terrain into the vacant magma chamber. Submarine volcanoes are non-explosive and their magma chambers are not emptied through violent eruptions, rather they eject low viscosity basaltic lava flows. Volcanic inflation at the site that persisted since the prior eruption in 1998 led to the suspicion that Axial Seamount would erupt again (Nooner and Chadwick, 2009). Though the extent of the effect this eruption has had on the seafloor is not yet concluded, it is estimated that several hundreds of thousands of cubic meters of magma was ejected from the magma chamber as it emptied. These new lava flows repaved Axial Seamount with an additional 12 feet of basalt (Chadwick et al., 2010). Seafloor maps of the lava flows that formed as a result of this eruption and altered the bathymetry of the seamount are essential to the precise installment of the cabled observatory. The RSN cabled observatory, which will provide real time data of events on and above the seafloor to scientists anywhere on the globe, is critical to the examination and mitigation of natural disasters on the west coast of the United States. The accessibility of, and conditions at Axial make it an exemplary location to monitor and study submarine volcanoes. These studies will provide a basis for understanding the manners in which similar geologic settings behave, and provide a baseline for Axial that will be used throughout the life of the cabled observatory (Chadwick et al., 2010).

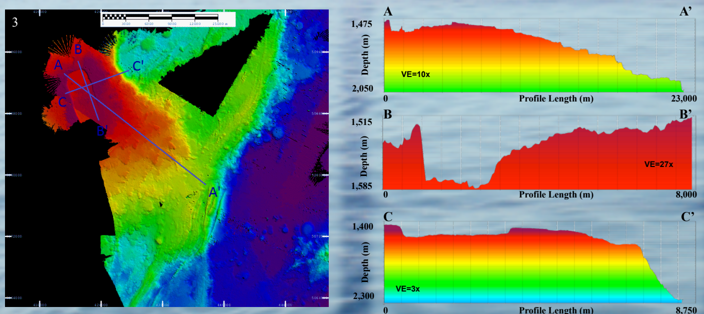


Figure 3: Map view of Axial Seamount, depth range 1475-2300 m. **Profile A-A':** Follows the path of the lava flows from the NW corner of the caldera to the termination of the visible flows at the base of the seamount to the SE flank. **Profile B-B':** Displays the length of the caldera in its entirety. Note the massive accumulation of lava within the caldera. **Profile C-C':** Displays the width of the caldera, highlighting the steep caldera wall along the western edge.

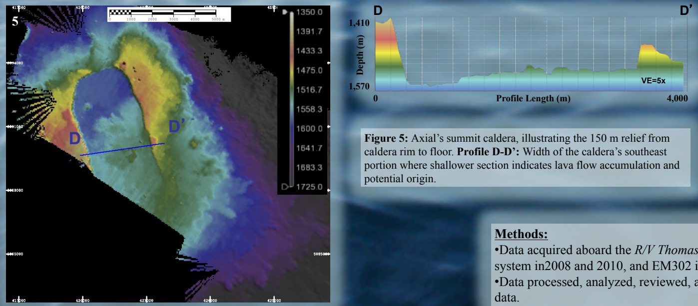
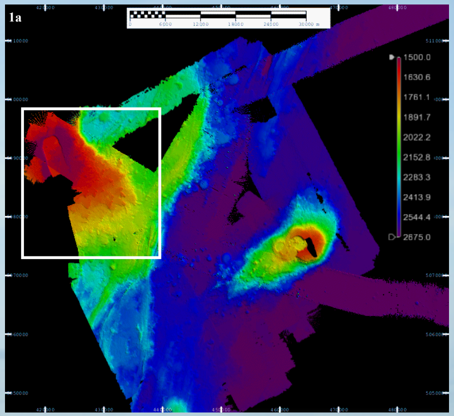


Figure 5: Axial's summit caldera, illustrating the 150 m relief from caldera rim to floor. **Profile D-D':** Width of the caldera's southeast portion where shallower section indicates lava flow accumulation and potential origin.



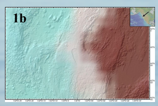


Figure 1: a) An overview of the bathymetry at Axial Seamount. The area in the white box is the portion of the seamount focused on in this study. **b)** Using GeoMapApp, an image was generated displaying the location of the Pacific and Juan de Fuca Plates relative to Axial's summit caldera.

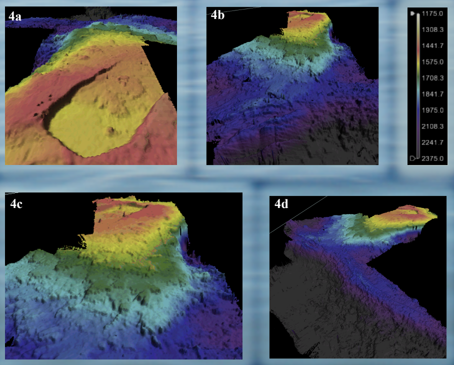


Figure 4: 3-D images of Axial's summit caldera and the flows associated with its various eruptions (3.9x vertical exaggeration, depth range from 1200-2300 m). **a)** View looking southeast from the top of the summit caldera showing steep caldera wall on NE side and raised lava source area in the southeastern portion of caldera **b)** View looking NW from the end of the visible lava flows on the SE edge of the seamount, showing full lateral extent of flows. **c)** Close-up of 4b. Note the lobes of overlying lava flows. **d)** View from E/NE showing extent of lava flow and the elevation to the east. This point represents the average sea floor depth as low 2500 m. The depth at the shallowest point of Axial's summit caldera is 1400 m.

Methods:

•Data acquired aboard the *R/V Thomas G. Thompson* of the University of Washington using a Kongsberg EM300 multi-beam sonar system in2008 and 2010, and EM302 in 2011.

•Data processed, analyzed, reviewed, and cleaned using CARIS HIPS & SIPS 7.1. 2D and 3D base images generated using cleaned data.

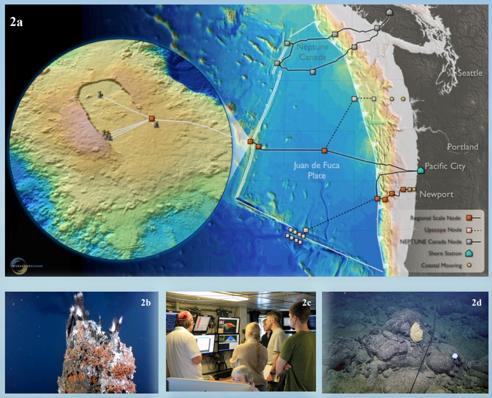


Figure 2: a) NSF OOI's Regional Scale Nodes sites. **b)** The top of El Guapo, an active black smoker at Axial. **c)** Scientists aboard the R/V *Thompson* interpreting newly collected data. **d)** Fresh pillow basalts discovered on the VISIONS '11 Cruise. Note the fiber optic cable. (images from Interactive Oceans)

Results and Discussion:

Our maps and 3-D images indicate that the 2011 eruption may have occurred in a SE direction. Although we are unable to map individual flows or structural features due to the 50 meter resolution of the data, general lava flow behavior and characteristics can be observed and follow trends of previous flows (Fig. 4). The direction in which lava migrates is a result of the slight offset of the rift zones on the north and south side of the seamount. The most likely source area of the eruption is the south end of the base of the summit caldera. This point lies along the southern rift zone, where fissures would be expected. Fissures are associated with dikes, linear channels that produce lava flows. Because dikes are a product of extensional deformation they typically run parallel to ridges (Delaney et al., 1998).

It is of substantial importance that we continue to observe the dynamics associated with Axial Seamount. Inflation of the caldera has been from 1998-2011 (Chadwick et al., 2009), which helps to determine when the next eruption is likely to occur, improving our knowledge of pre-eruptive processes associated with submarine volcanoes globally.

Acknowledgements:

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