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Fluid composition or bottom currents: What drives extremes in behavior of plumes at ASHES vent field, Axial Volcano?

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November 24, 2022

Abstract

The Cabled Observatory Vent Imaging Sonar, otherwise known as COVIS, has acquired several months of plume centerlines and strengths for several vents in the ASHES vent field of Axial Seamount. COVIS was initially installed at ASHES vent field in July 2018 and acquired imaging data throughout July-September 2018 and since July 2019. COVIS uses acoustic imaging to monitor the strength and behavior of the plumes formed above black smokers and diffuse discharge sites in an approximately 40 m by 40 m region which includes Inferno and Mushroom vents. Preliminary observations suggest that the plumes above Inferno are highly variable; sometimes a distinct rising column is seen to expand with height while other times there is little acoustic evidence for a plume at all. Potential explanations range from variable discharge rates to variable discharge salinity driving collapsing plumes to extremes in bottom currents. The obvious simple explanation of bent plumes produced by extreme bottom currents is unsatisfactory as such bent (even horizontal) plumes should be visible in the acoustic imaging data. Initial explorations of the impact of near seawater salinity variations suggest this is a plausible explanation for variations in plume maximum height independent of heat content. However, the paucity of recent or continuous salinity and temperature sampling on Inferno limits the certainty of interpretations suggesting variations in venting. In contrast to the variable plumes, the sulfide mounds of the region (Inferno, Mushroom, Hell and Phoenix) appear as consistent (stable) silhouettes in the acoustic images. On Inferno, we can even see indications of the thin chimneys on top of the mound from which primary venting occurs. Preliminary work is focused on refining the classification of acoustic returns between rock, sulfide, and water to see if we can track the growth (and collapse) of the actively venting chimneys.

OS51B-1493 - Fluid composition or bottom currents: What drives extremes in behavior of plumes at ASHES vent field, Axial Volcano?

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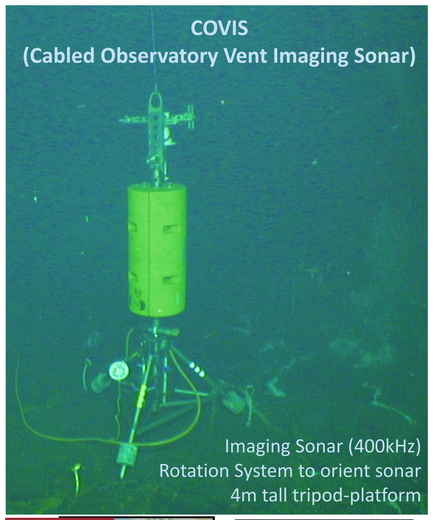
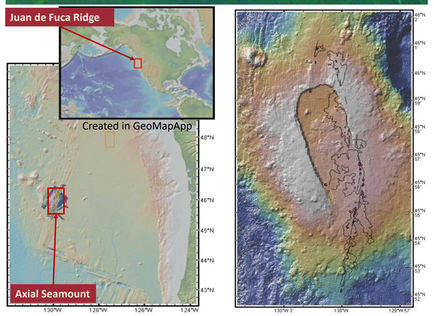
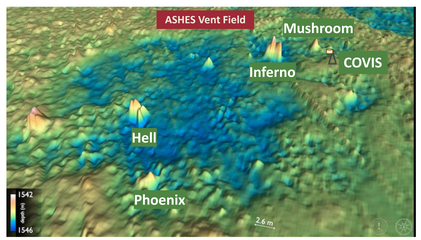
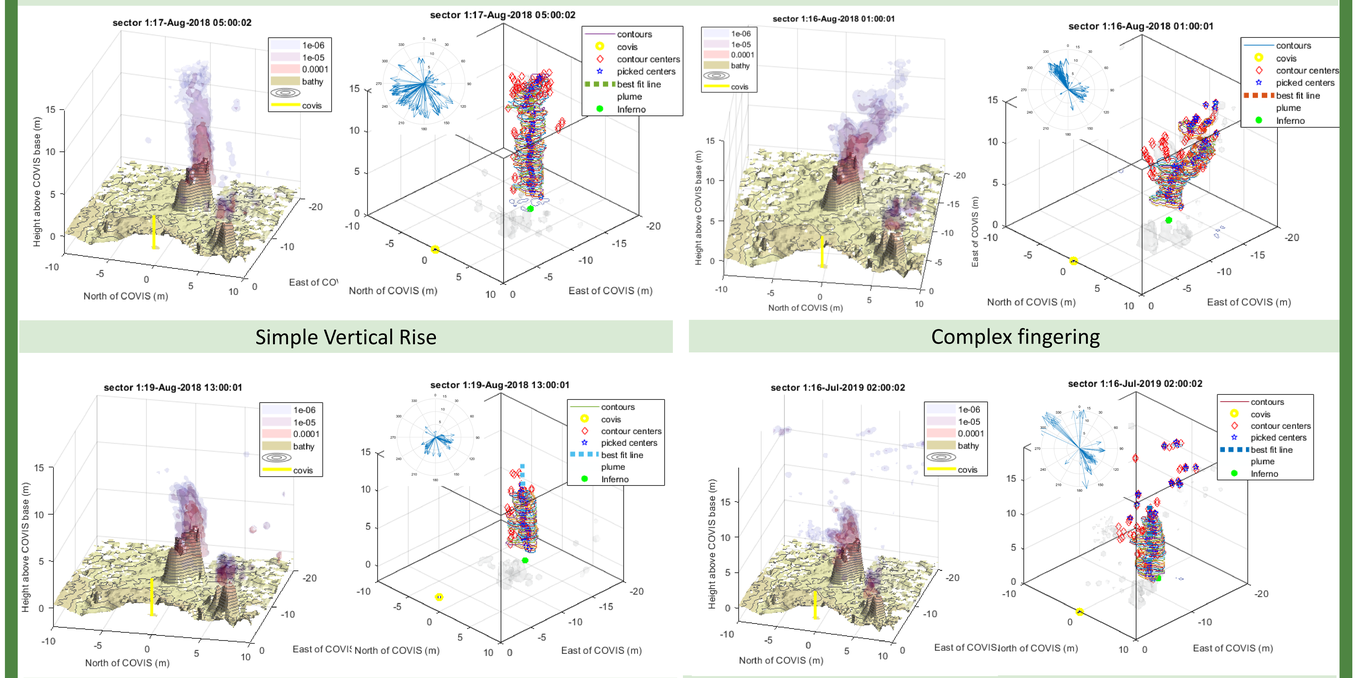
COVIS (Cabled Observatory Vent Imaging Sonar)







Plume structure varies from ….



Simple Vertical Rise

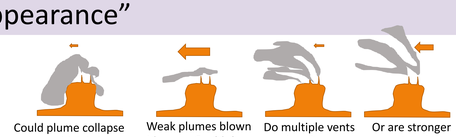
Not there?

Complex fingering

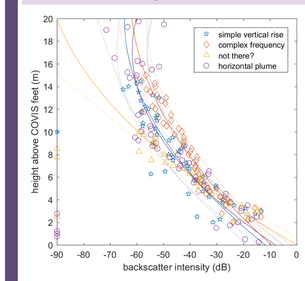
Horizontal Plumes

Alternative Explanations for Plume "Disappearance"

- ❑ variable discharge rates → Vent Intensity data shows no smoking gun here
- ❑ variable discharge salinity driving collapsing plumes → NO EVIDENCE! Need salinity data to assess.
- ❑ extremes in bottom currents → bent (even horizontal) plumes should be visible in the acoustic imaging data AND they are. So why no plume sometimes?

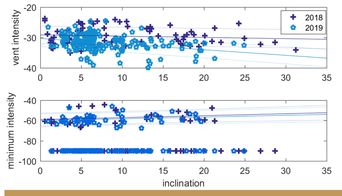


Plume Style vs Vent & Plume Intensity



Little backscatter difference for edifice (0-4m), chimney (4-6 m), or venting (4-6m) levels. Complex fingering plumes may be associated with more intense venting. Times with apparently missing plumes show lowest backscatter.

BUT overall no significant differences.



Contrary to prior sites (Xu et al., 2013; poster OS51B-1494), vent level intensity shows more sensitivity to currents than the upper (diluted) plume.

References

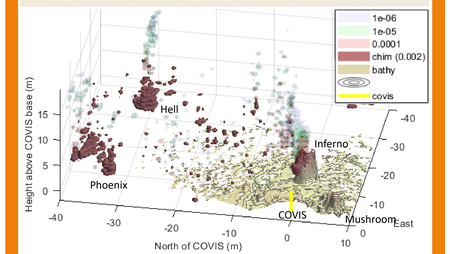
Turner, 1966, Jets and plumes with negative or reversing buoyancy, J. Fluid Mechanics, 26,779-782.

Ernst, et al., 2000, Vertical and lateral splitting of a hydrothermal plume at Steinaholl, Reykjanes Ridge, Iceland. *EPSL*, 179, 529-537.

Ernst, Davis, and Sparks. Bifurcation of volcanic plumes in a crosswind, *Bull. Volc.*, 56, 159-169.

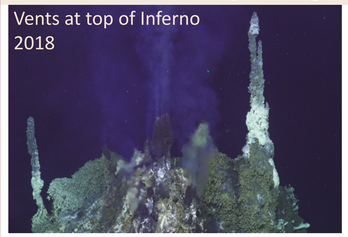
Xu et al., 2013, Observations of the volume flux of a seafloor hydrothermal plume using an acoustic imaging sonar, G-cubed.

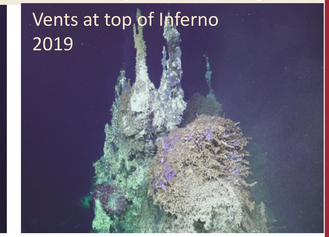
Check out the mounds of Hell and Phoenix!

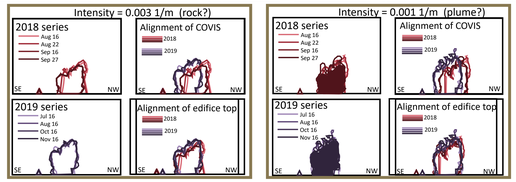


The consistent (stable) silhouettes in the acoustic images for Hell and Phoenix suggest we could get better bathymetry for the area with intelligent processing of the imaging data.

As locus of venting changes, chimneys fall and grow





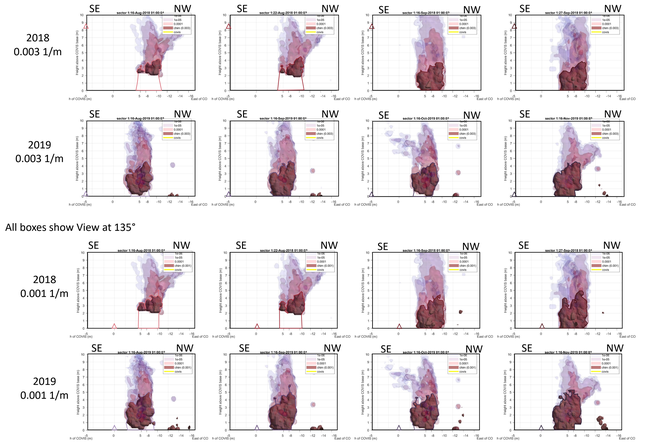


Observations (isovalue=0.003 1/m):

- COVIS was moved summer 2019 (front edge of edifice different distance from COVIS in 2018 than 2019). Does this explain the differences in edifice height between 2018 & 2019?
- Edifice appears to have shrunk during Sept 2018 but regrown by Jul 2019. Did COVIS move during early Sept 2018?

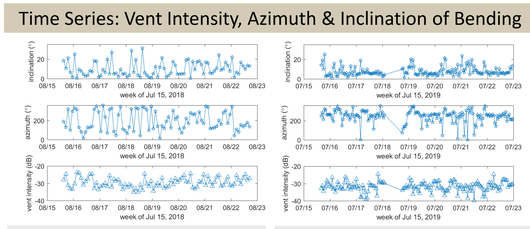
Observations (isovalue=0.001 1/m):

- Fingering above more solid (higher isovalue) edifice suggests plumes or chimneys and indicates loci of venting.
- In 2018, two strong loci with maybe a third weaker one are apparent. In 2019, at least three strong loci of venting are apparent with some shift of venting towards NW corner. Did venting increase?



Potential Monitoring Data Products

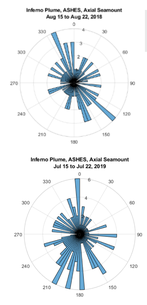
Time Series: Vent Intensity, Azimuth & Inclination of Bending



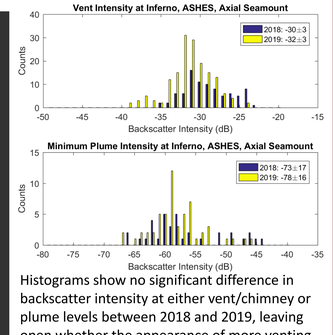
Aug 15-22, 2018

Jul 15-22, 2019

Highly bent plumes (>15° inclination) are less common in 2019, despite similar intensities of venting. Current directions appear to shift between 2018 and 2019.



Dominant Current Directions



Histograms show no significant difference in backscatter intensity at either vent/chimney or plume levels between 2018 and 2019, leaving open whether the appearance of more venting loci (acoustics) or the growth of a new chimney (photos) affected the total vent output.

NSF OCE **1736702, 1736393, 1726920, 1736621**