Tracking Down Hydrothermal Vents at the Mariana Back-Arc

Expedition: Hydrothermal Hunt at Mariana

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Scattered along the barren ocean floor lie numerous, unexplored hydrothermal vent sites — oases of hot, chemical-rich, life-nurturing fluids. These sites are similar to underwater versions of the hot springs and geysers at Yellowstone National Park.

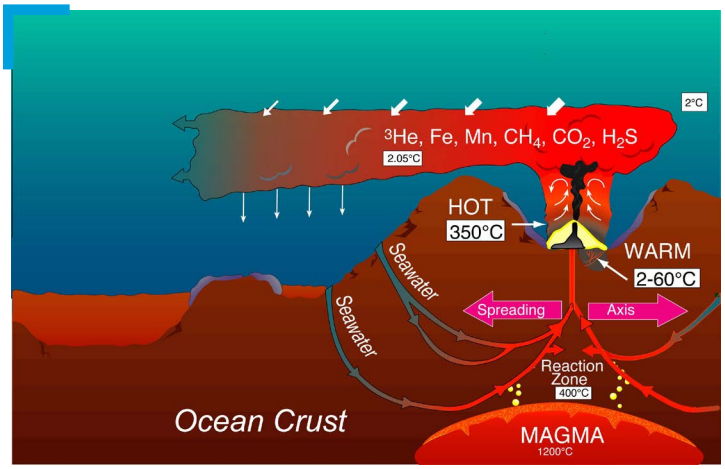
How Do Hydrothermal Vents Form?

Cold seawater in deep cracks within Earth's crust is heated by cooling magma, becomes buoyant, and rises to the seafloor. Instead of forming a warm pond, as at Yellowstone, the hot fluid rises like a hot-air balloon into the cold ocean, cooling as it mixes with the frigid seawater. Mixing continuously dilutes the hot discharge and increases its volume as it rises, until the hydrothermal plume achieves neutral buoyancy and is dispersed by local ocean currents. This hydrothermal circulation pattern occurs wherever seafloor cracks can channel seawater to layers of hot rock.

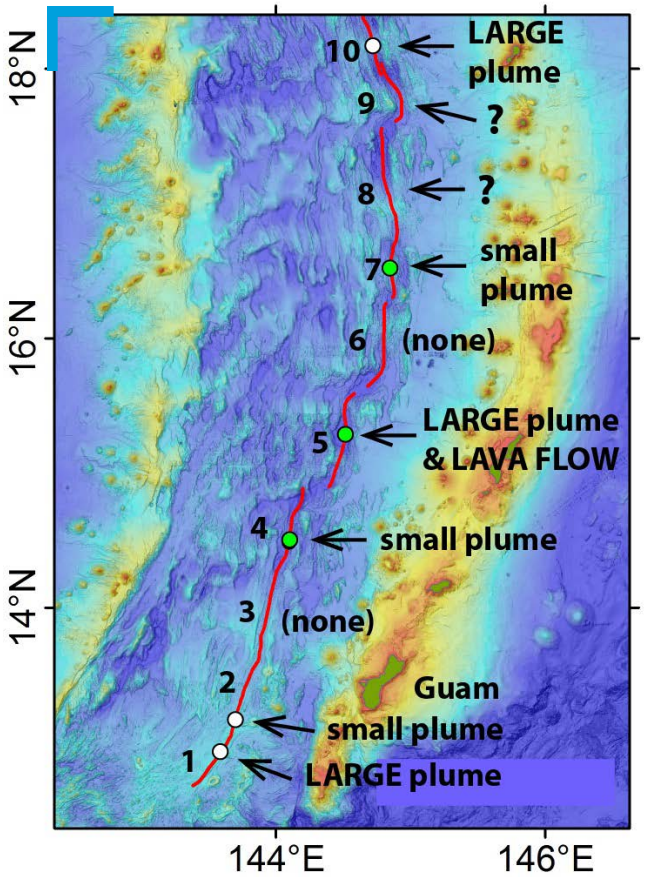
First, You Need a Good Map

One of our main goals during this expedition (Hydrothermal Hunt at Mariana, 2015) on R/V *Falkor* was to determine where hydrothermal vent sites lie along an area in the western Pacific Ocean called the Mariana Back-arc.

The first step in searching for vents is to develop a detailed map of the seafloor. Underwater topographic maps called bathymetric maps precisely define the shape of the seafloor. Seafloor bathymetry provides a roadmap that greatly narrows our search by identifying the path along the seafloor where the most recent seafloor spreading is occurring. On the Mariana Back-arc, seafloor spreading has created a broad valley whose size rivals the Grand Canyon. It is here where deep, still-molten magma may be powering active vents.



Graphic of a vent at a spreading center forming a hydrothermal plume as adapted from Massoth et al., 1988 (not to scale). *Image courtesy of the Schmidt Ocean Institute.*



Mariana Back-arc map, showing which numbered segments have been found to be hydrothermally active. White dots are previously known sites; green dots are newly discovered during this cruise. *Image courtesy of Schmidt Ocean Institute, Bill Chadwick.*

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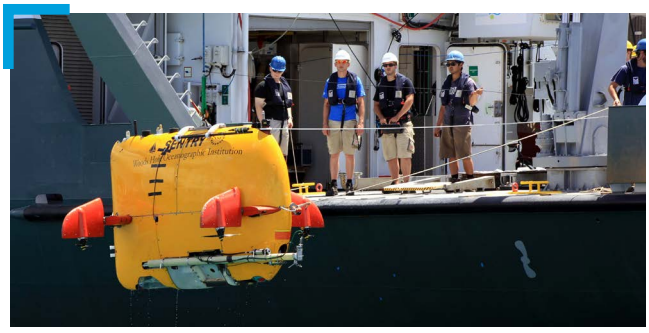
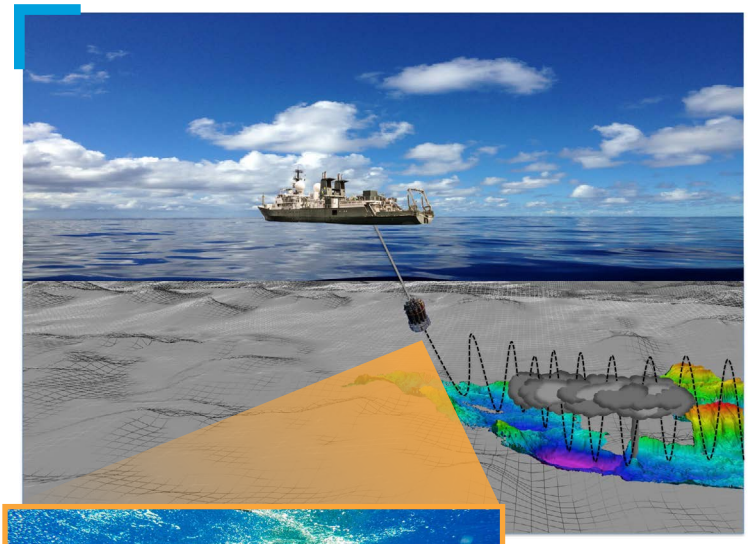
Hunting for Plumes

Our search was challenging because the active discharge openings of vents are small, scattered, and difficult to find. We greatly enhance the chance of success by searching first for the telltale plumes the vents emit, and not the vents themselves. As a trail of wind-blown smoke draws the eye to a smokestack, oceanographers use maps of hydrothermal plume tracers that lead back towards a field of vents. The tracers can be physical measurements such as changes in temperature, salinity, and turbidity of the water. Chemical characteristics of the plume are also used, including various trace metals and gases common in a hydrothermal discharge.

To map these plumes, we have two powerful tools on board. The first is a basic instrument, used by oceanographers around the world called a Conductivity, Temperature, and Depth (CTD) profiler. It includes specialized sensors to detect specific chemical tracers and bottles to collect water samples. We tow the CTD behind the ship, a few hundred meters above the seafloor, as we slowly travel along the spreading center path, collecting data to identify likely vent locations. To precisely locate the vents themselves, we next deploy a better bloodhound, *Sentry*. *Sentry* is an autonomous underwater vehicle (AUV) that can navigate precise grids over the seafloor and use a variety of sensors to "sniff out" the source of a hydrothermal plume. Ultimately, *Sentry* flies closer to the seafloor than the CTD, making high-resolution sonar maps or capturing images of animal life and the vent sites themselves.

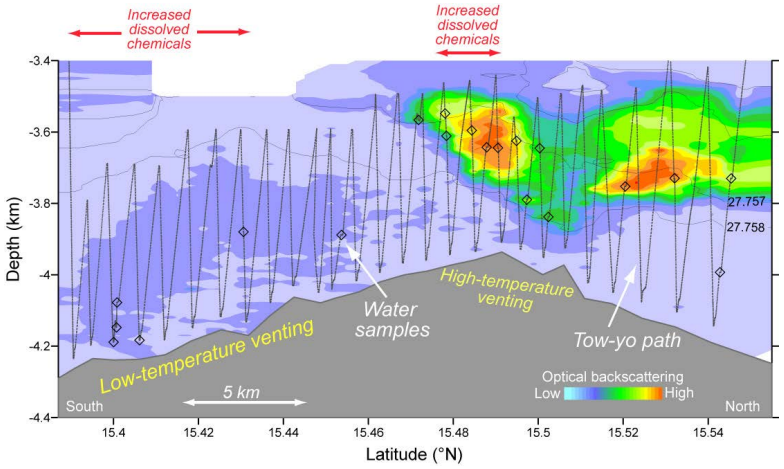


Woods Hole Oceanographic Institution's *Sentry* team and SOI crew practice deploying the AUV *Sentry* off the aft deck of *Falkor*. *Image courtesy of Schmidt Ocean Institute, Carlie Wiener.*



Drawing of a "CTD tow-yo" showing how the CTD instrument is raised and lowered on a cable as the ship drives slowly forward, allowing it to map the location and sample hydrothermal plumes near the seafloor. *Image courtesy of Schmidt Ocean Institute, Colleen Peters.*

CTD released just below the surface. *Image courtesy of Schmidt Ocean Institute, Mark Heckman.*



The visualization of hydrothermal plumes based on optical backscattering. High backscattering values indicate more suspended hydrothermal particles. Low-temperature venting produces high concentrations of dissolved chemicals but almost no particles. High-temperature venting produces many particles as well as dissolved chemicals. *Image courtesy of Schmidt Ocean Institute, Thom Hoffman.*

THINK ABOUT IT...

Q: How might the discovery of new hydrothermal vent sites and communities contribute to possible breakthroughs in science?

Original Cruise Log: https://schmidtocean.org/cruise-log-post/tracking-down-hydrothermal-vents/
Expedition: https://schmidtocean.org/cruise/hydrothermal-hunt-at-mariana/
Baker (bio): https://schmidtocean.org/person/edward-baker/
Vents (diagram): https://schmidtocean.org/wp-content/uploads/fk151121-guam-20151123-baker-plume.jpg
Map: https://schmidtocean.org/wp-content/uploads/fk151121-guam-20151210-chadwick-backarcmap-lores.jpg
CTD Tow-Yo (drawing): https://schmidtocean.org/wp-content/uploads/fk151121-guam-20151204-baker-ctdtowyo_lores.jpg
CTD (image): https://schmidtocean.org/wp-content/uploads/ctdreleasedjustundersurface11-18-14markheckman.jpg
Plume Visualization: https://schmidtocean.org/wp-content/uploads/fk151121-guam-20151204-baker-plume.jpg
AUV *Sentry*: https://schmidtocean.org/wp-content/uploads/sentrytrialswiener.jpg

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