Hydrothermal Vents

http://www.ocean.udel.edu/deepsea/level-2/geology/vents.html

http://www.resa.net/nasa/images/ocean/smoker.jpg

Some History

- First discovered in 1977.
- Average depth ~7000 ft.
- Temperature as high as 400^{o}C; water doesn’t boil due to high pressure (~300 atm).
- “Smokers” formed when super-hot vent water meets the cold deep ocean water (~2^{o}C).
- Metals: Fe, Mn, Cl, Ca,K, Li, Cu,Zn, and Pb.

Hydrothermal Vents

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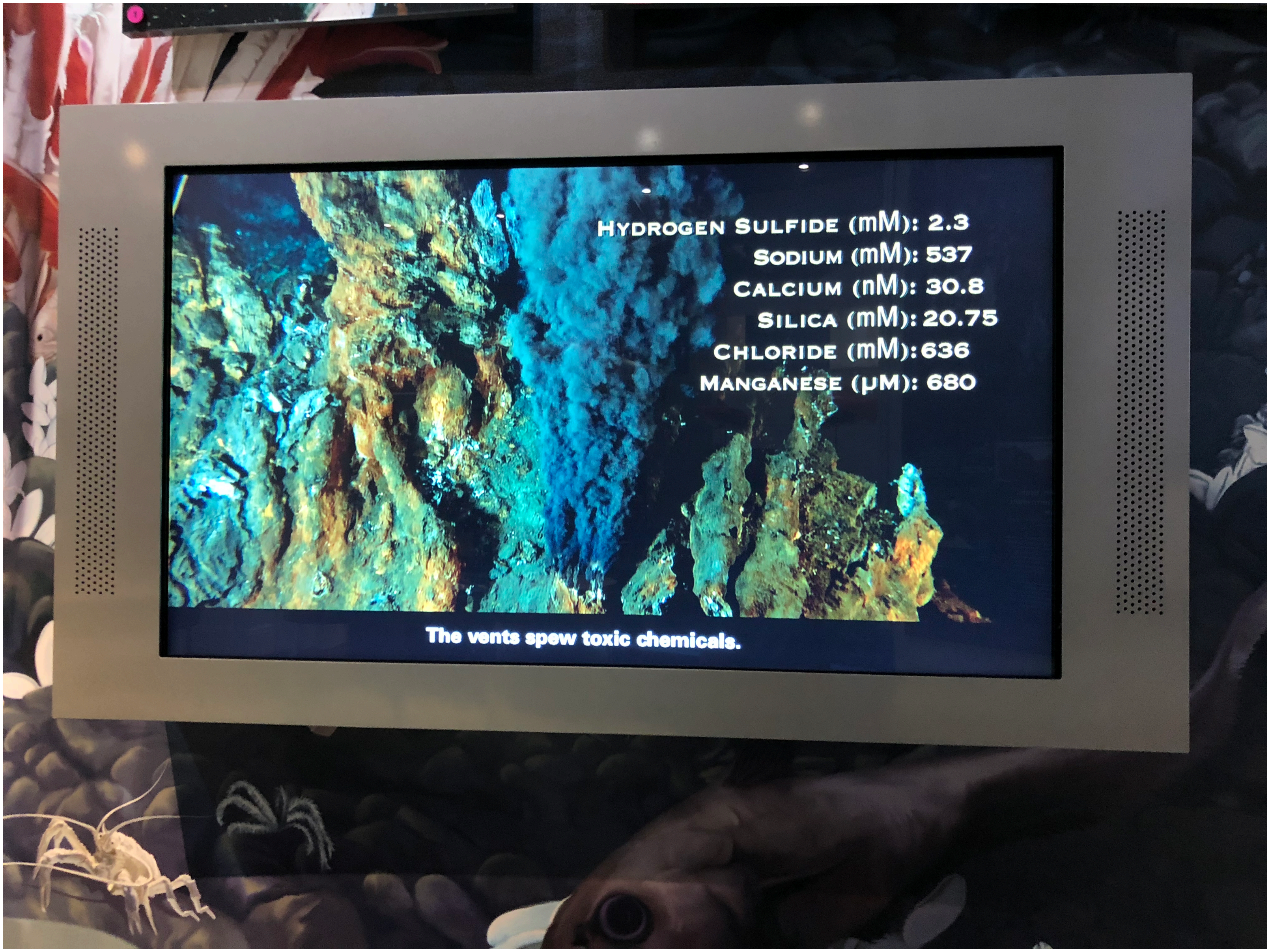
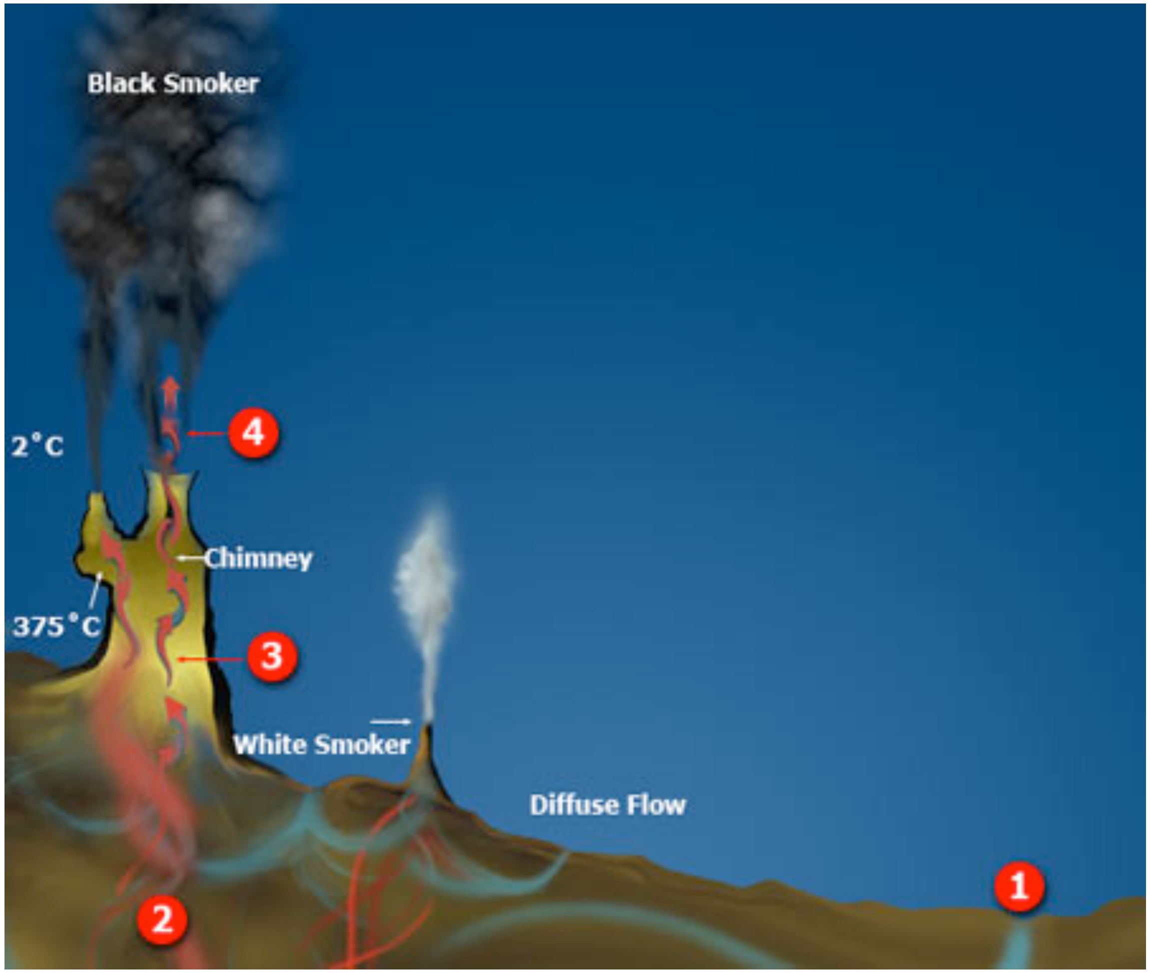


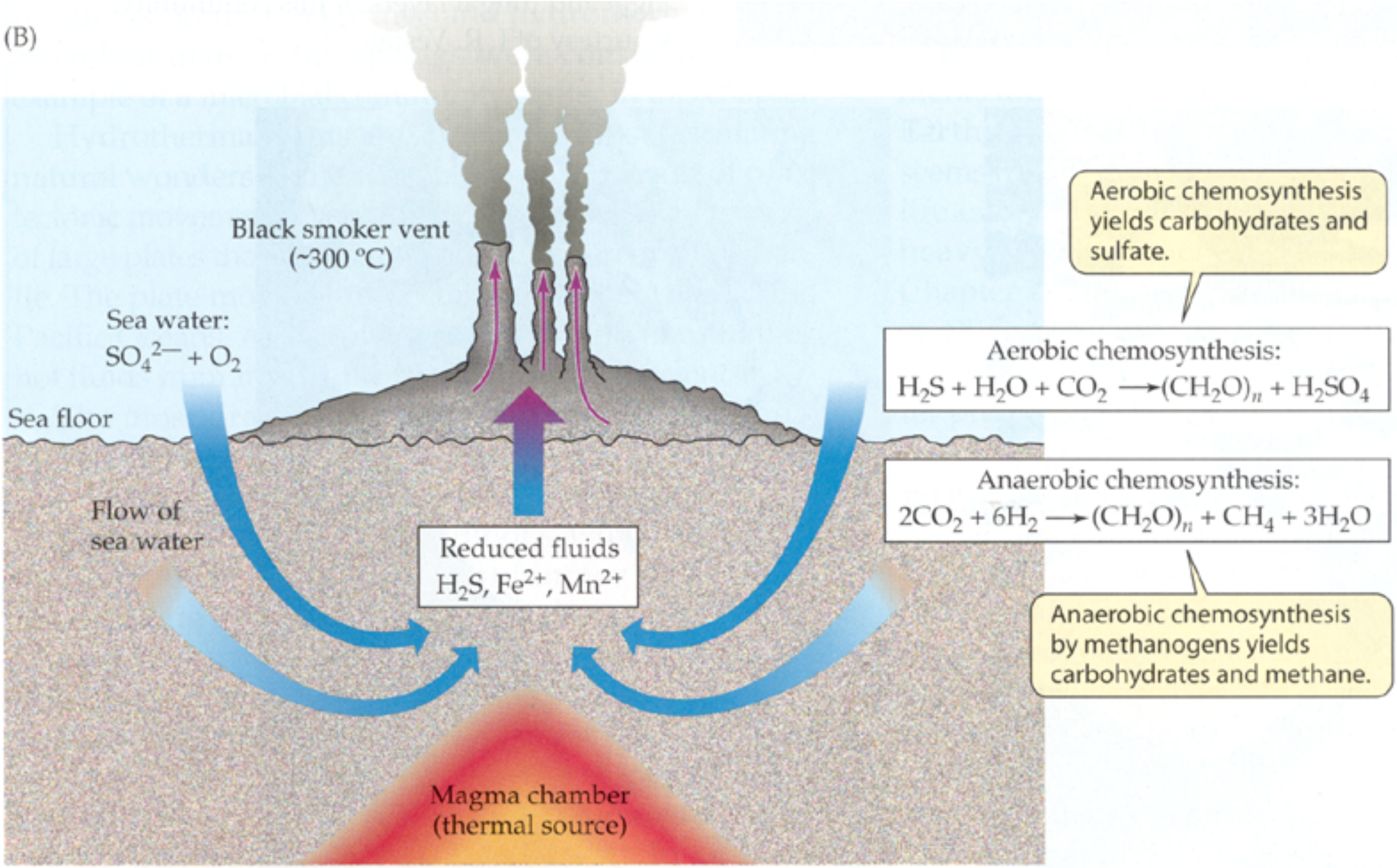
Some Worldwide Locations of Hydrothermal Vents

A Black Smoker Hydrothermal Vent

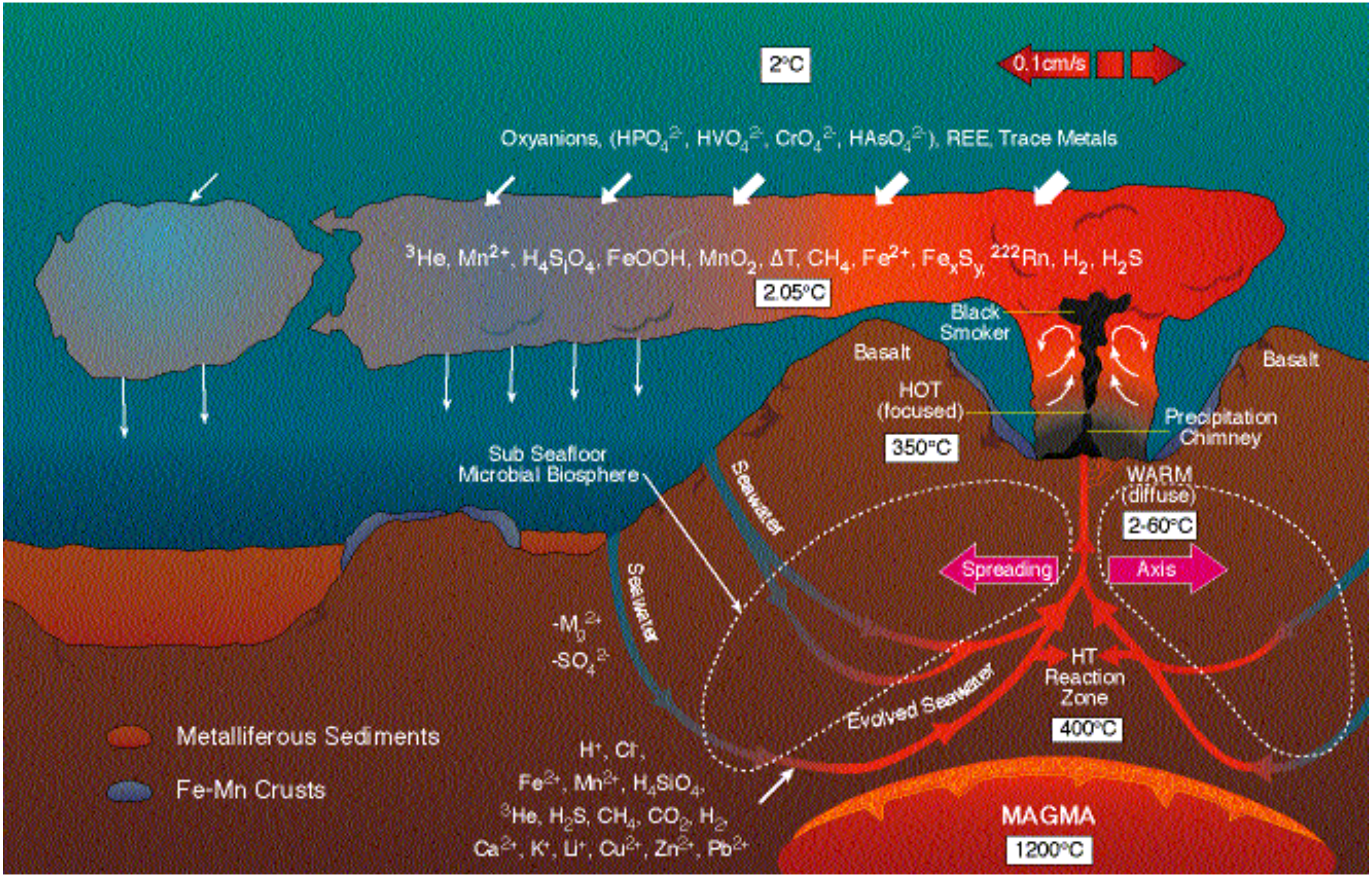


http://www.divediscover.whoi.edu/vents/vent-infomod.html#

1. Cold sea water (2^{o}C) seeps down through cracks into the ocean floor.
2. Seawater continues to seep; the water's temperature is raised to 350 – 400^{o}C for black smokers; reacts with rocks in the ocean crust; chemical reactions change the water by: a) Oxygen is removed, b) it becomes acidic (pH~2.8), c) picks-up dissolved metals (Fe, Cu, and Zn) and H_2S.
3. The hot liquid rises because it's density is less than that of cold liquids. The hot liquid carries the dissolved metals and sulfide with it.
4. Hot fluid exits the chimney. Rxn triggered by cold temperature and oxygen present in seawater. White smokers (250 – 300^{o}C) – this Rxn happens before exiting the chimney.



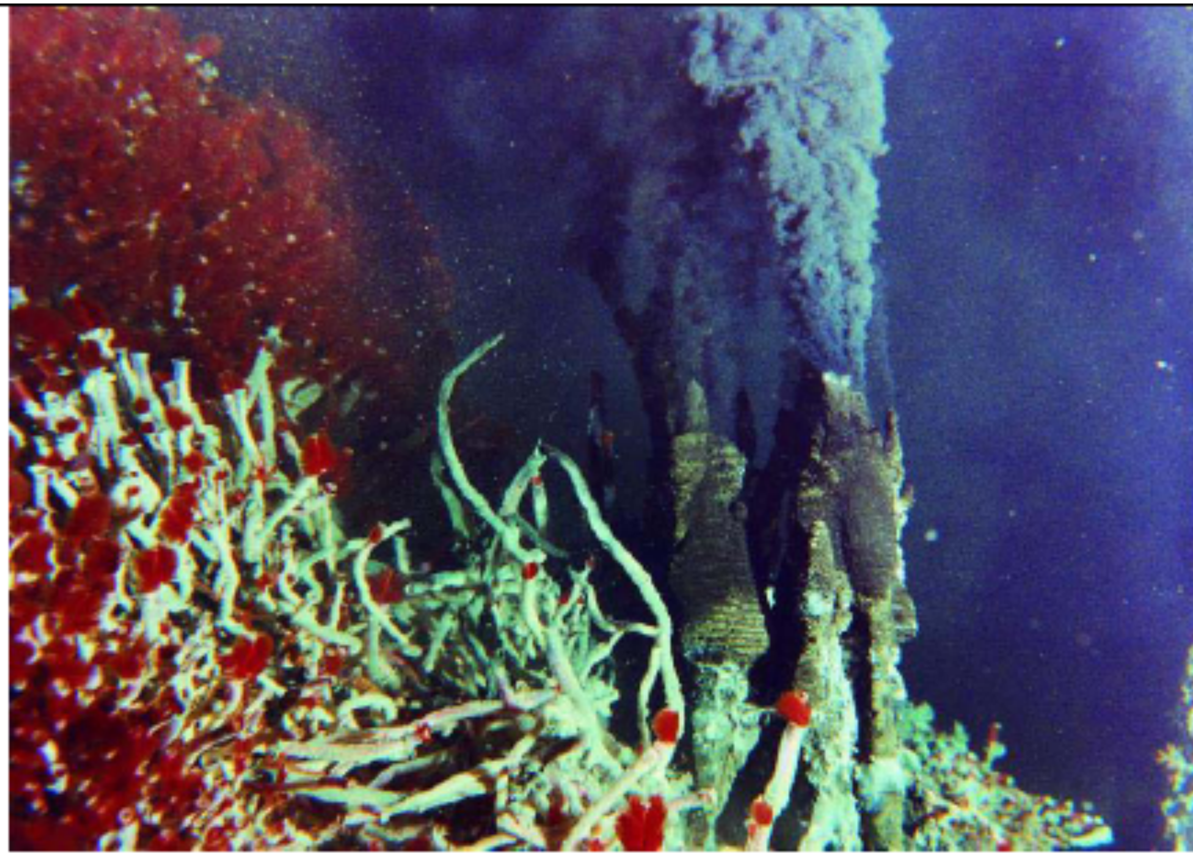
(B)
Black smoker vent
(~300 °C)
Sea water:
$SO_4^{2-} + O_2$
Sea floor
Flow of
sea water
Reduced fluids
H_2S, Fe^{2+}, Mn^{2+}
Magma chamber
(thermal source)
Aerobic chemosynthesis yields carbohydrates and sulfate.
Aerobic chemosynthesis:
$H_2S + H_2O + CO_2 \longrightarrow (CH_2O)_n + H_2SO_4$
Anaerobic chemosynthesis:
$2CO_2 + 6H_2 \longrightarrow (CH_2O)_n + CH_4 + 3H_2O$
Anaerobic chemosynthesis by methanogens yields carbohydrates and methane.



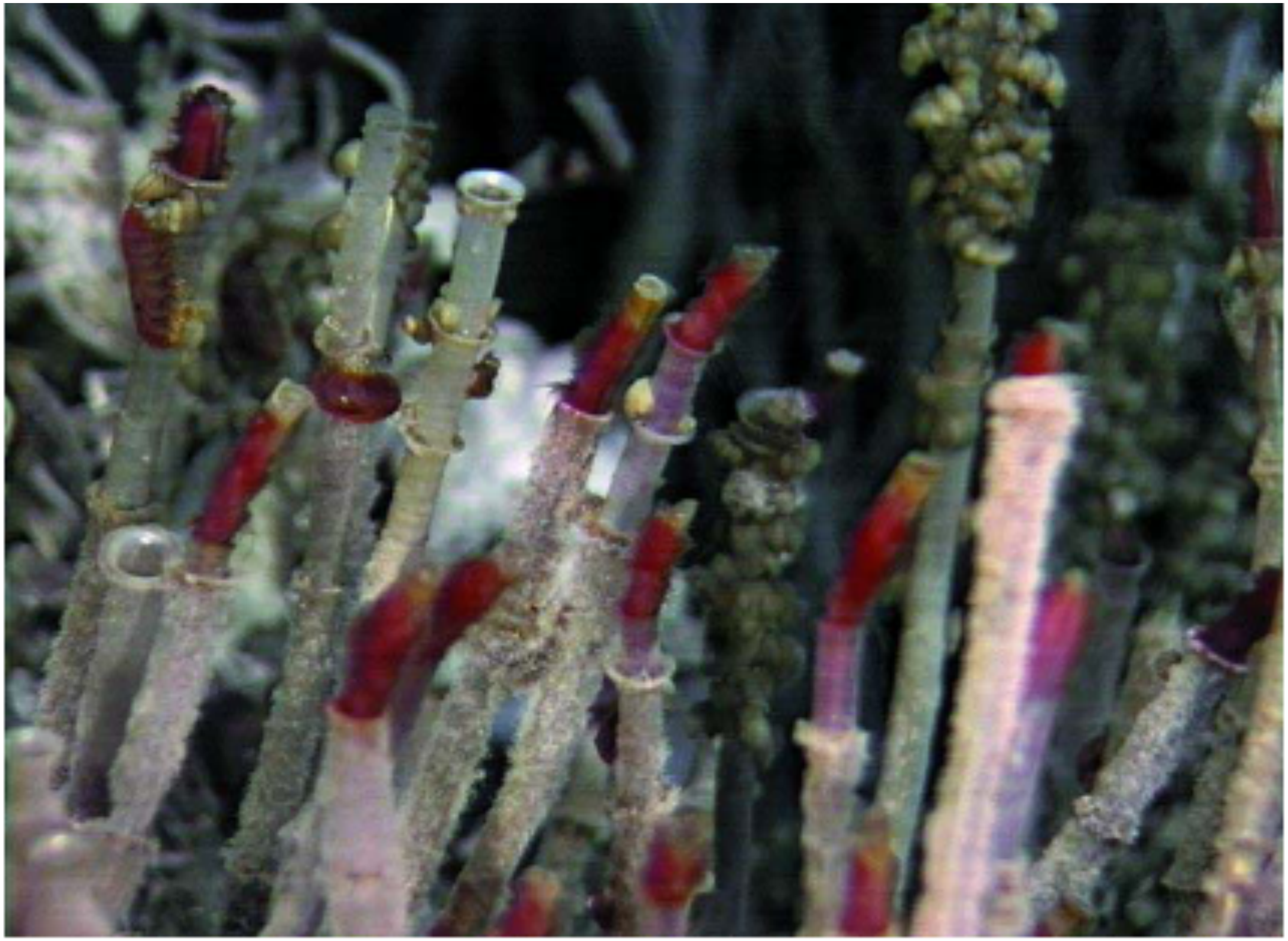
Hydrothermal Vent Chemistry

Hydrothermal Vents

Hydrothermal Vents

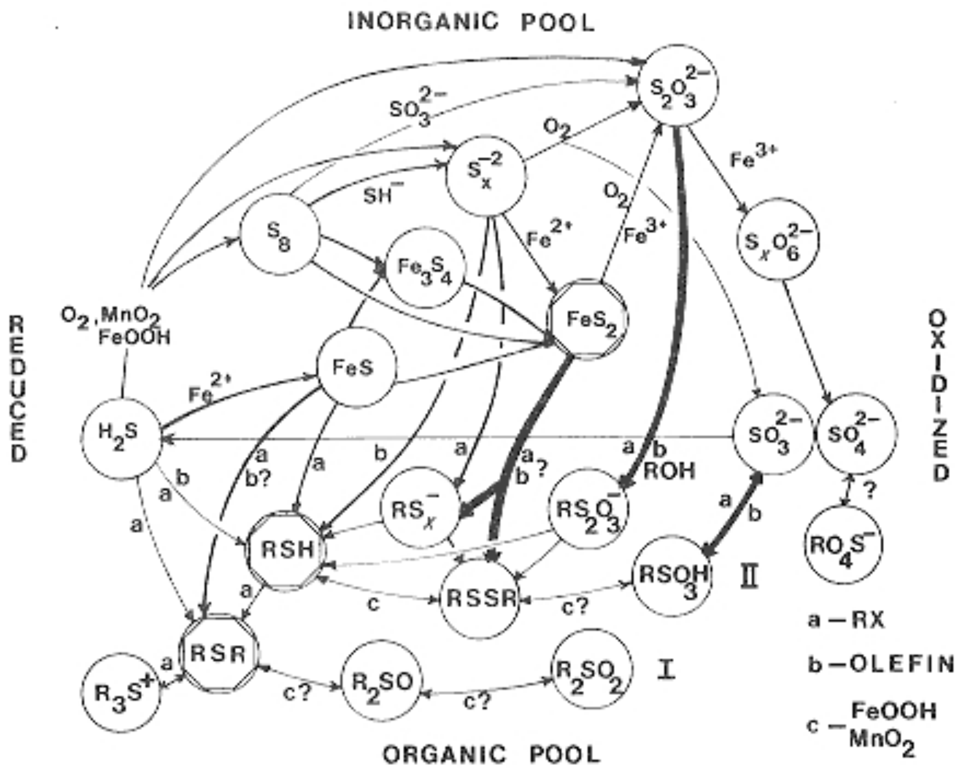


Black Smoker with Worms!



Some Worms

Sulfur Speciation in Hydrothermal Vents



$S_2O_3^{2-}$

SO_3^{2-}

S_8

SO_2

H_2S

SH^-

S^{2-}

SO_4^{2-}

HSO_4^-

H_2SO_4

Sulfur Speciation in Hydrothermal Vents

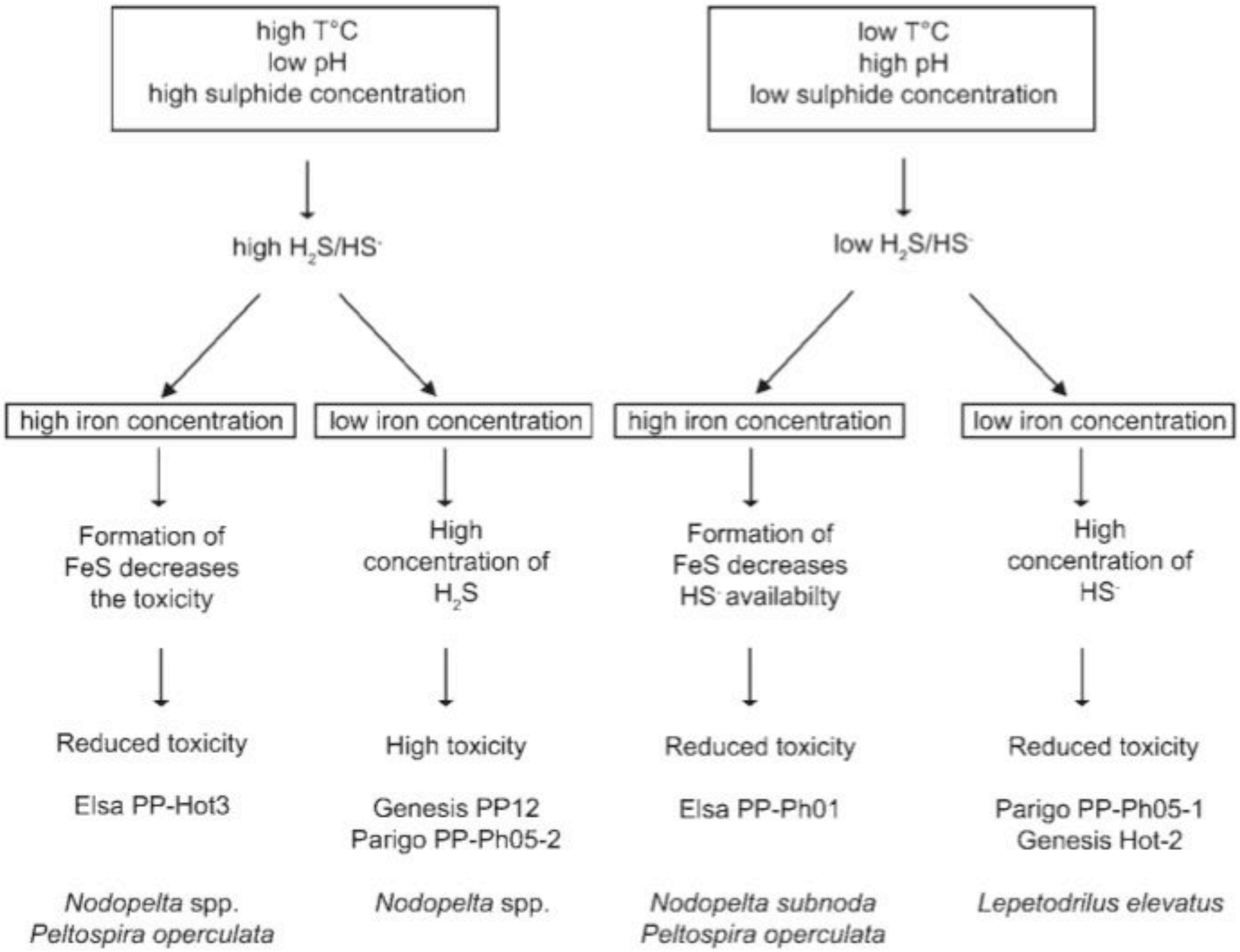
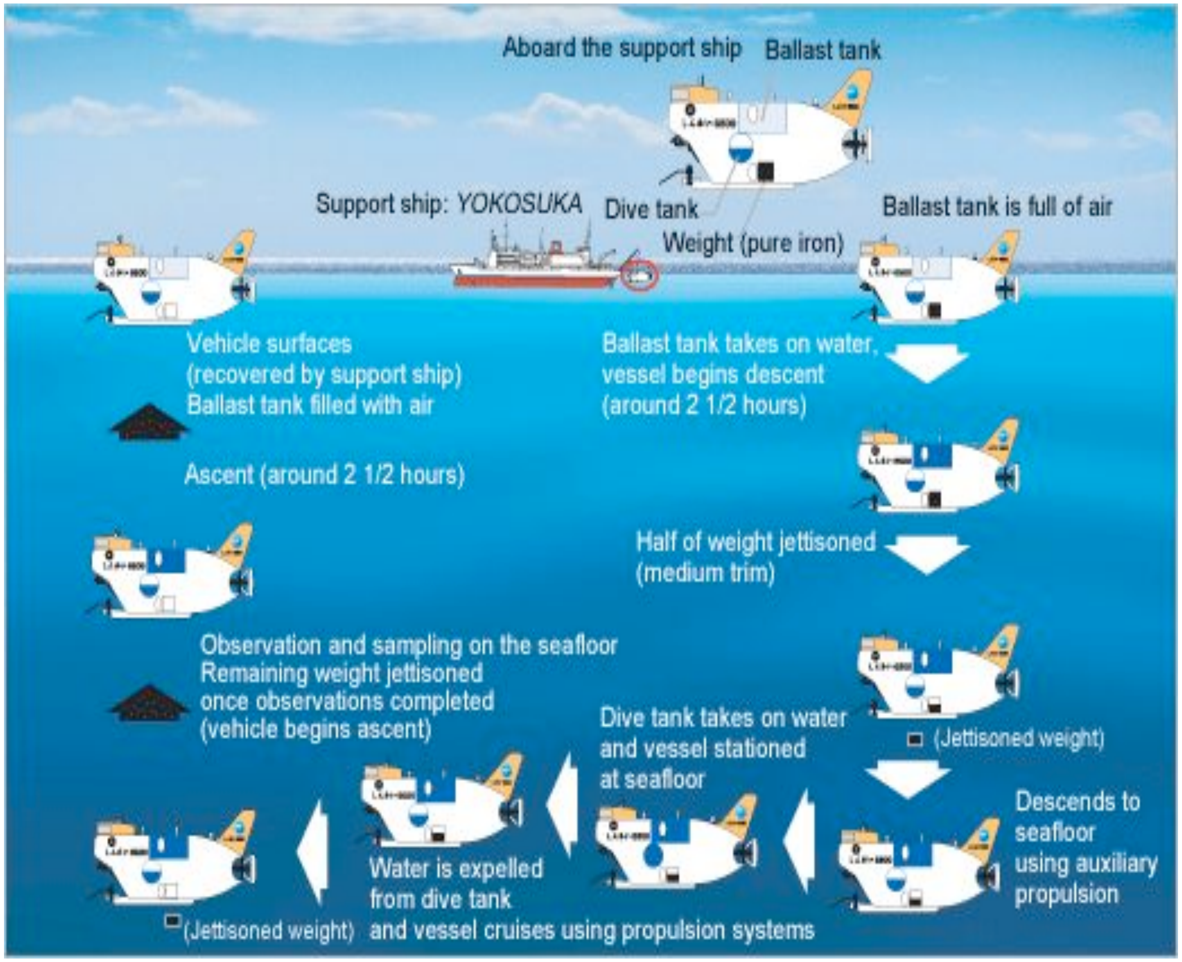
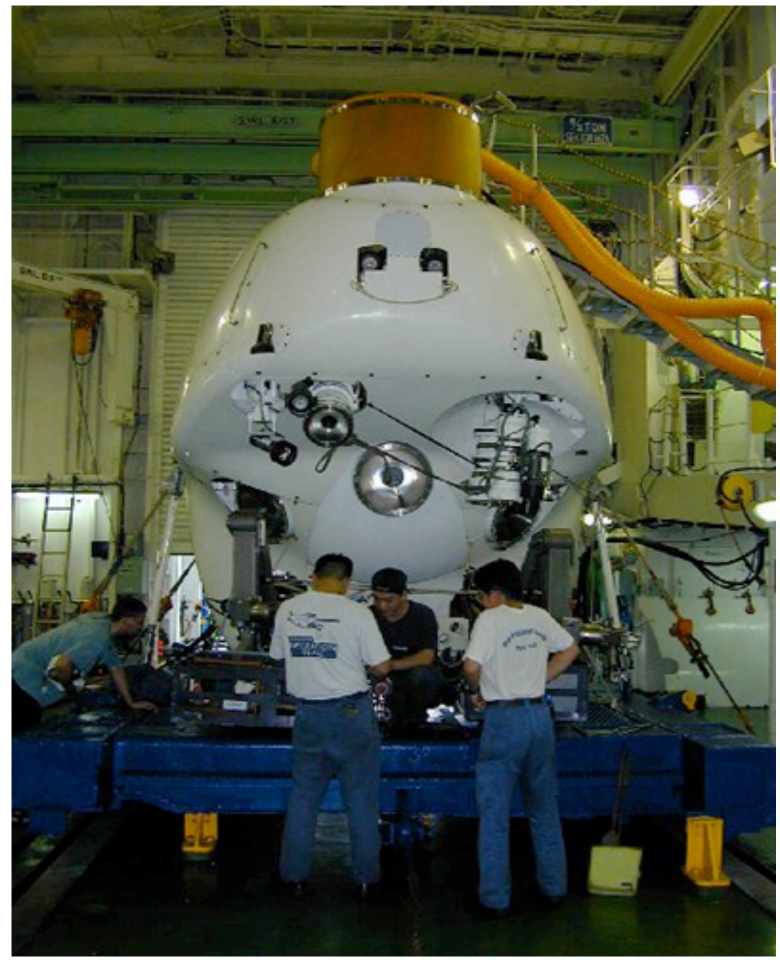


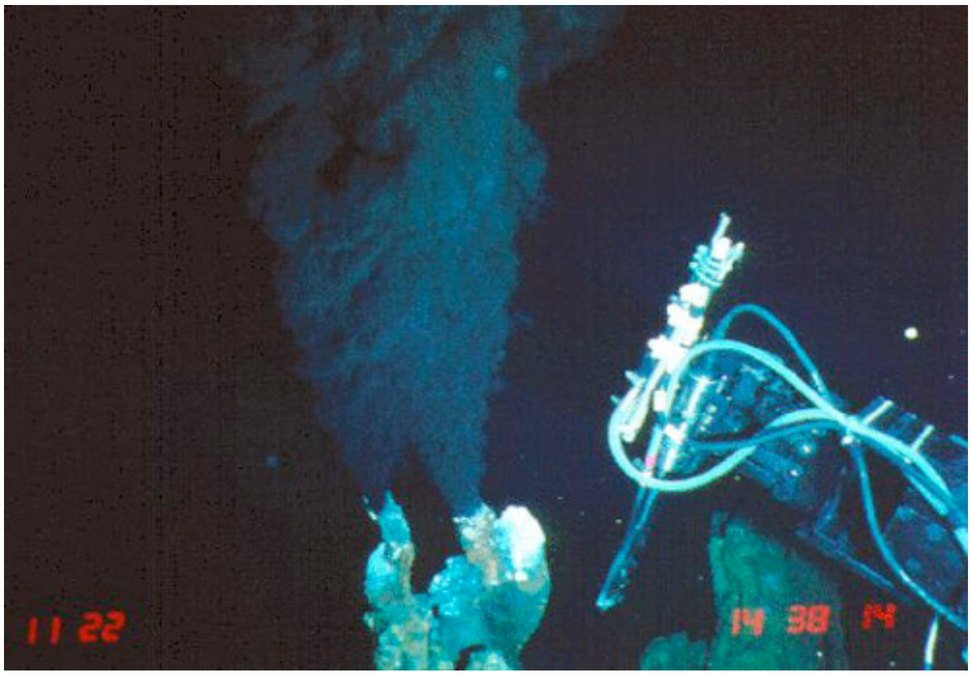
Fig. 6. Schematic representation of the influence of physico-chemical variables on the gastropod community structure for the different vents from the 13°N/EPR hydrothermal vent field. Toxicity of the different habitats was determined from the interactions between total sulphide concentrations, pH, and iron concentrations. For each habitat, dominant gastropod species are indicated.

pH measurements with the Shinkai 6500 at a depth of 4000 m.

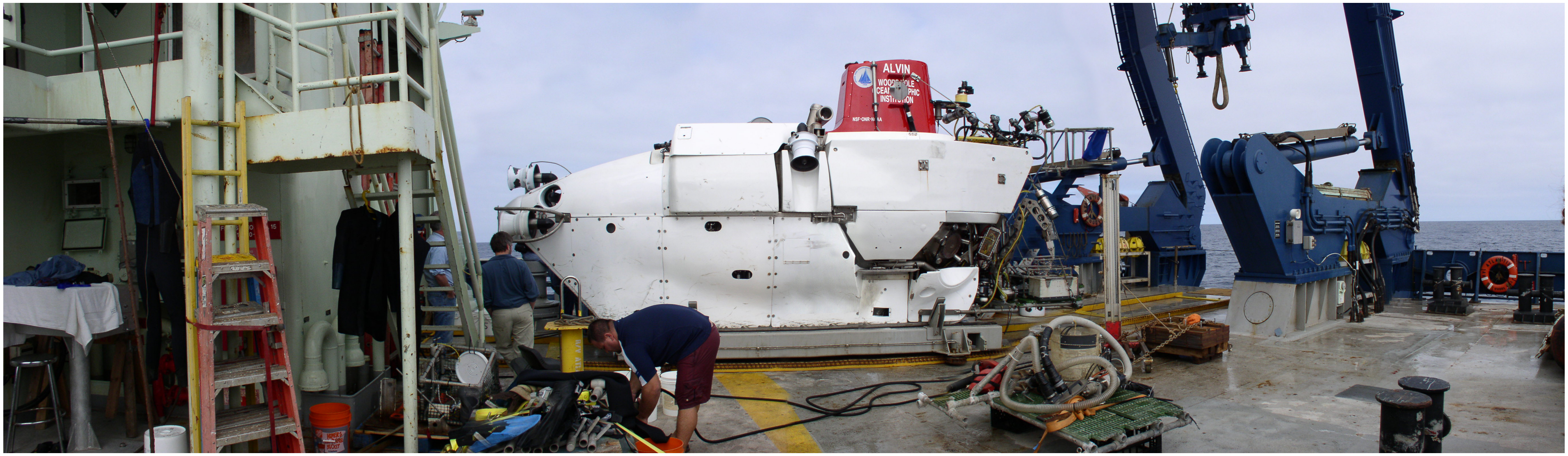




pH measurements with the Shinkai 6500 at a depth of 4000 m.



Vent measurements with Alvin DSV-2

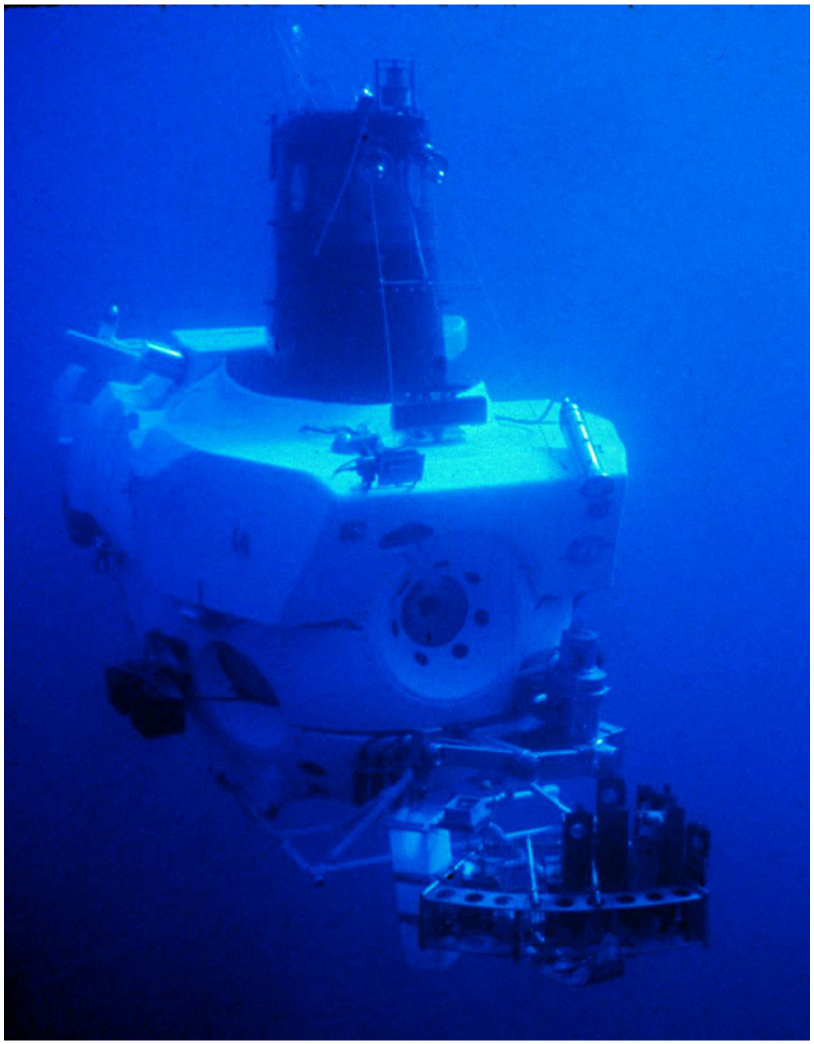


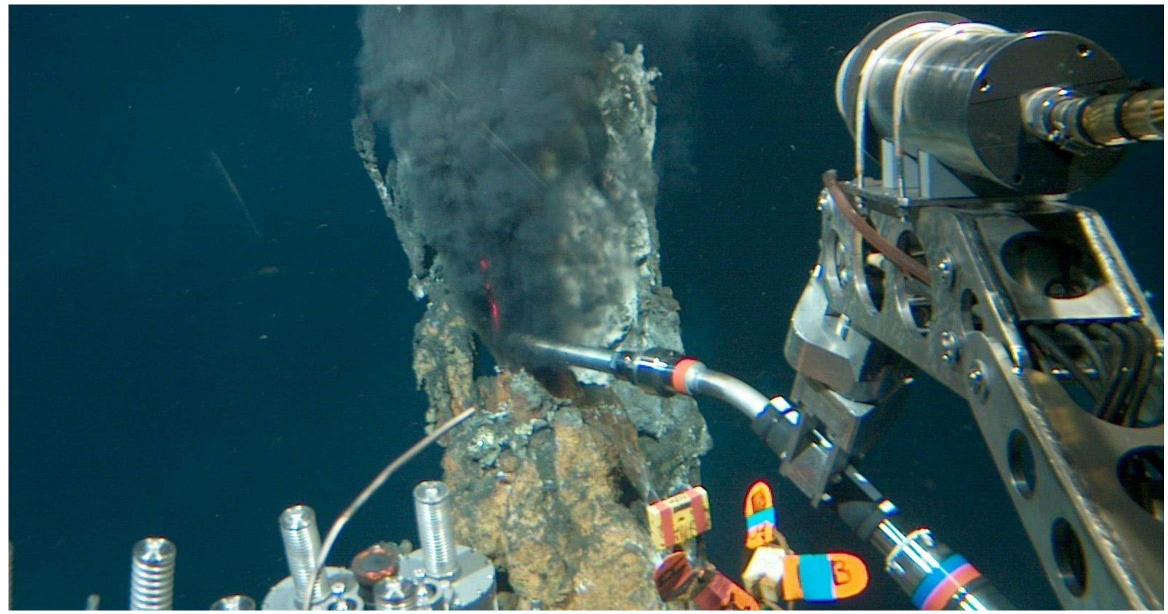
Alvin (DSV-2) is a manned deep-ocean research submersible owned by the United States Navy and operated by the Woods Hole Oceanographic Institution (WHOI) in Woods Hole, Massachusetts. The vehicle was built by General Mills' Electronics Group[2] in Minneapolis, Minnesota. Named to honor the prime mover and creative inspiration for the vehicle, Allyn Vine, Alvin was commissioned on 5 June 1964. The submersible is launched from the deep submergence support vessel RV Atlantis (AGOR-25), which is also owned by the U.S. Navy and operated by WHOI. The submersible has made more than 4,400 dives, carrying two scientists and a pilot, to observe the lifeforms that must cope with super-pressures and move about in total darkness, as well as exploring the wreck of Titanic. Research conducted by Alvin has been featured in nearly 2,000 scientific papers.

https://en.wikipedia.org/wiki/DSV_Alvin

Vent measurements with Alvin DSV-2

2500 ft = 250 atms





https://en.wikipedia.org/wiki/DSV_Alvin

The Identification of Redox Species from Hydrothermal Vents by in situ Raman Spectroscopy: Instrumental analysis of DORISS
Monterey Bay Aquarium Research Institute

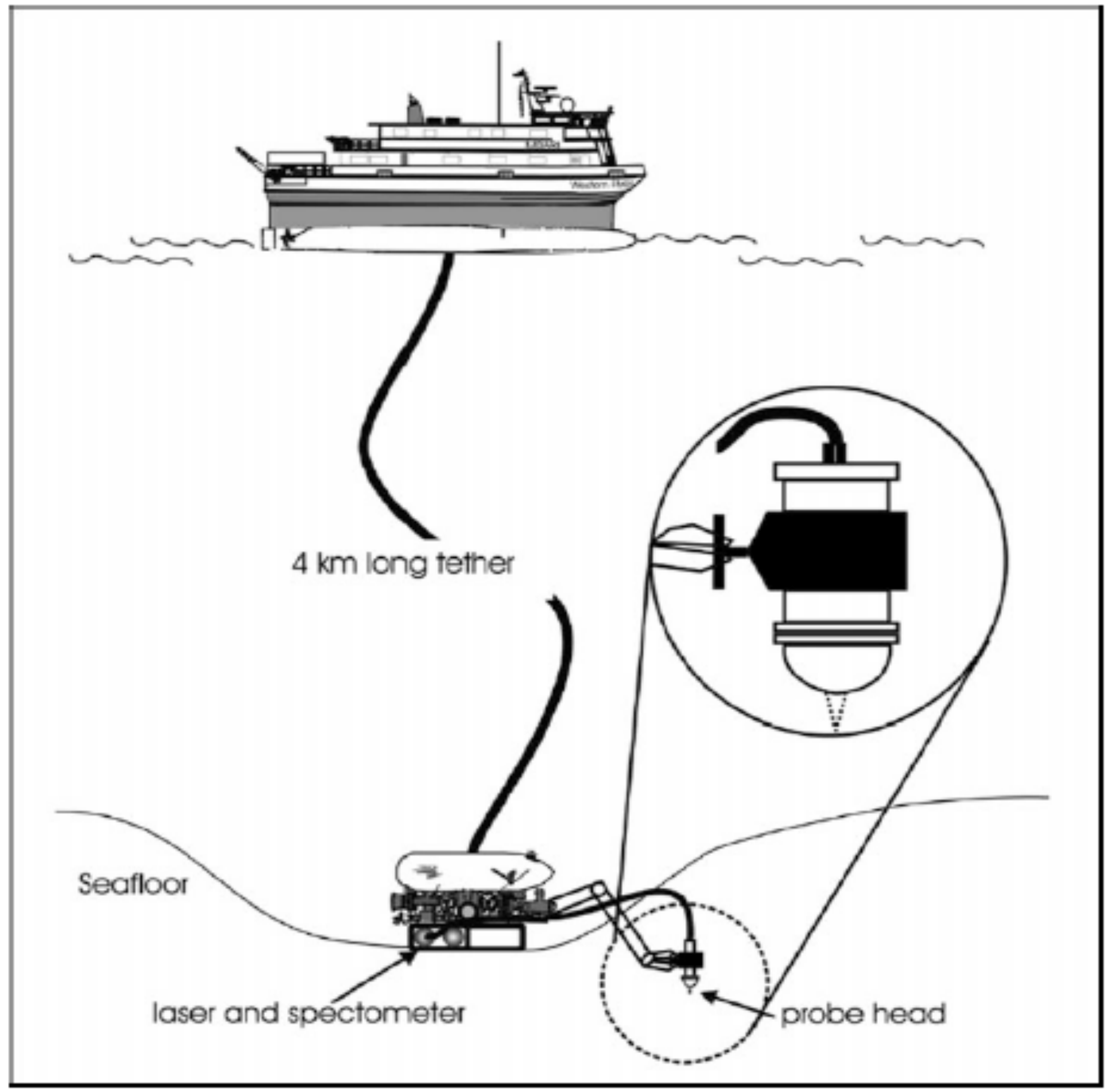
Deep Sea Raman In Situ Spectrometer, developed by MBARI

Raman scattering:
a vibrational spectroscopy

Raman active species in sea waters are measured.

Examples include:

CH_4, CO_2, CO, H_2S, H_2, CO_3^{2-}, and SO_4^{2-}



The Identification of Redox Species from Hydrothermal Vents by in situ Raman Spectroscopy: Instrumental analysis of DORISS
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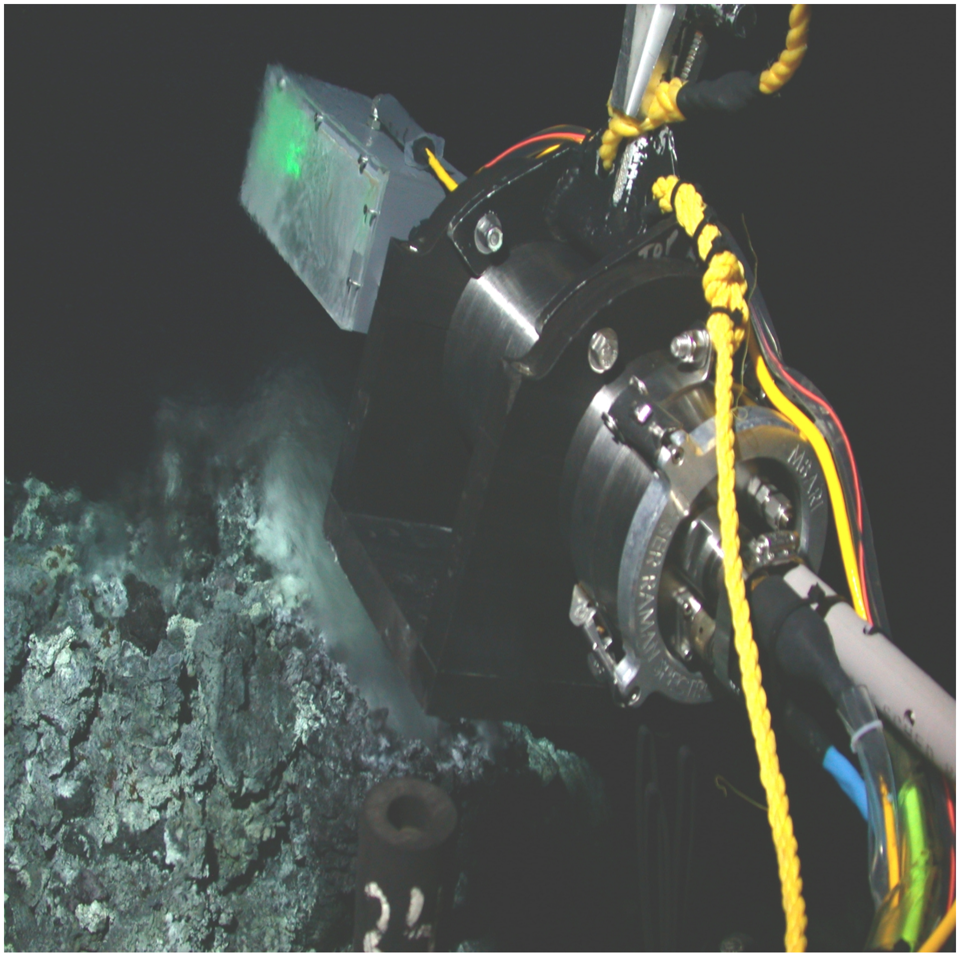
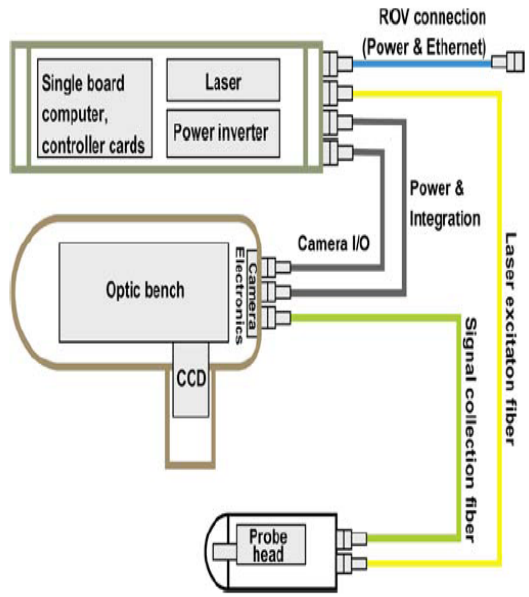
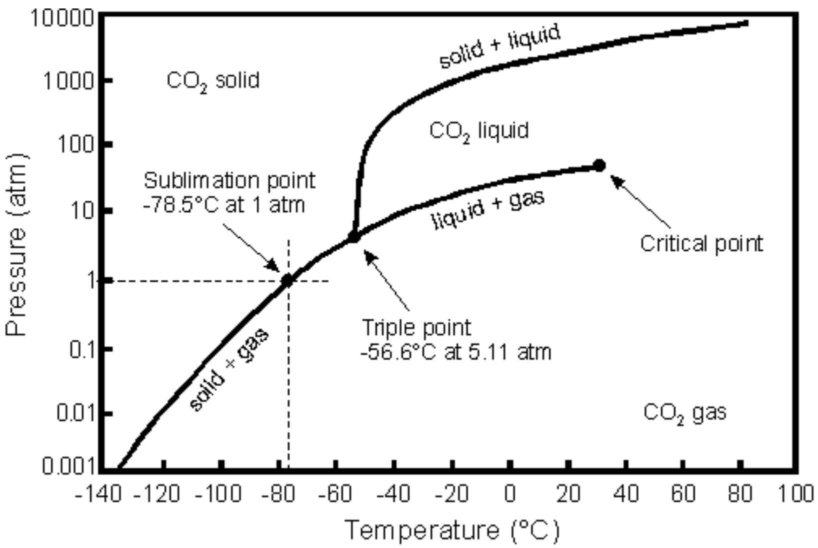


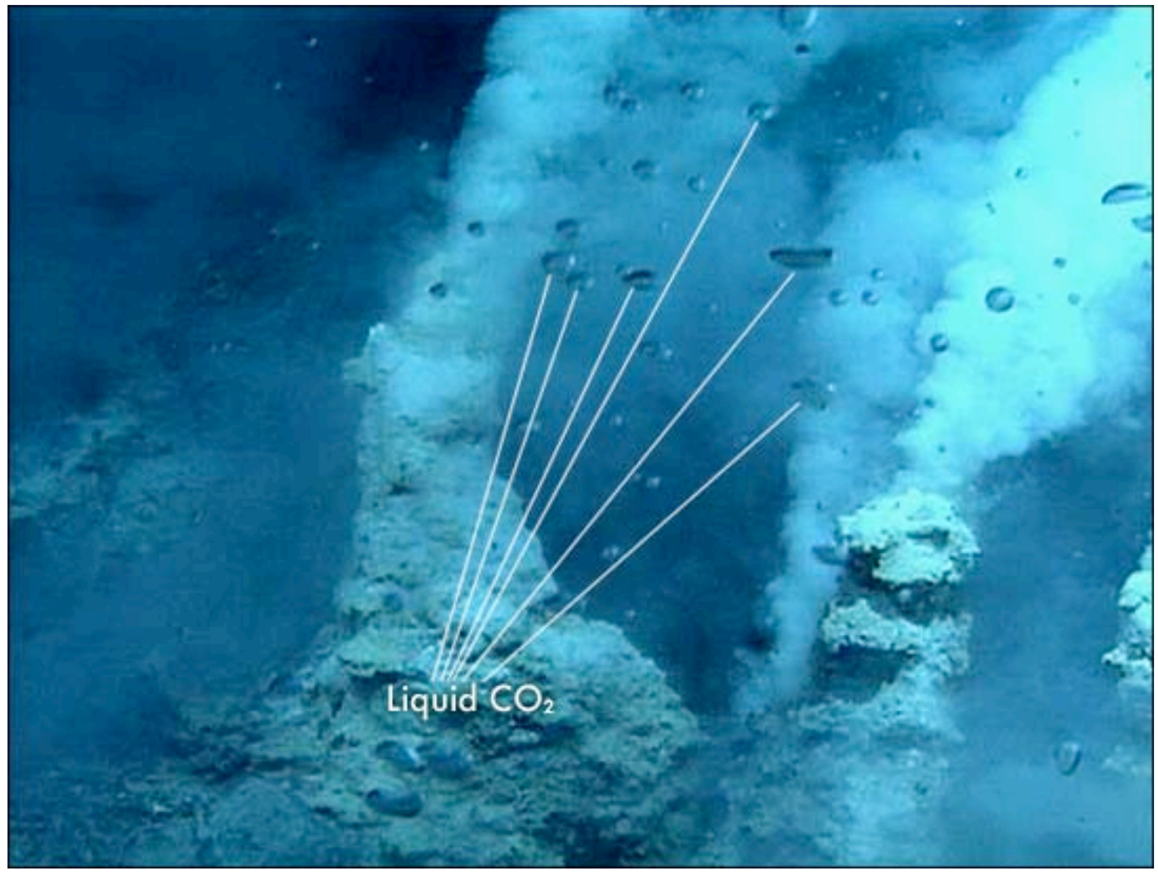


http://www.mbari.org/raman/hydrothermal.htm

Carbonate Speciation at Thermal Vents



Pressure-Temperature phase diagram for CO_2.



CO_2 on the Ocean Floor?

Sea sediment storage proposed for carbon dioxide

It may be possible to fight global warming by burying carbon dioxide in reservoirs hundreds of meters below the ocean floor.

The developers of the concept contend that the global deep sea storage capacity of CO2 is virtually unlimited, and that the area within the 200-mile economic zone of the US coastline is capable of storing thousands of years of current US CO2 emissions. Carbon dioxide could be stored in reservoirs hundreds of meters below the ocean floor. Kurt Zenz House, a geoscientist at Harvard University, and his colleagues propose injecting CO2 into sea floor sediments at depths of at least 3,000 meters, where the cool temperature and high water pressure would transform CO2 into a dense liquid. At such high pressures, liquefied CO2 could eventually turn into solid crystals at temperatures of 8-10°C.

Kurt Zenz House, Daniel P. Schrag, Charles F. Harvey, and Klaus S. Lackner; Permanent carbon dioxide storage in deep-sea sediments PNAS, August 7, 2006.

Trapping Carbon Dioxide In An Icy Cage: Researchers Explore The Ocean Floor With Rare Instrument

In collaboration with oceanographers from the Monterrey Bay Aquarium Research Institute (MBARI), a team of geologists at Washington University in St. Louis is using a rare instrument on the ocean floor just west of California. One of their earliest projects was to see if it's possible to capture carbon dioxide from the atmosphere and store it on the ocean floor. The geologists, headed by Jill Pasteris, Ph.D., professor of earth and planetary sciences in Arts & Sciences, and their MBARI colleagues are the first to deploy a Raman spectrometer on the ocean floor. The instrument combines a portable focusing lens with a potent laser to examine minerals, gases and liquids – even seawater itself. Pasteris' group and their MBARI colleagues are using Raman spectroscopy to see what carbon dioxide in either a pure liquid or a complex solid phase will do on the sea floor. They also are examining the feasibility of synthetically trapping carbon dioxide in solids called clathrate hydrates, ice-like solids that form a cage around gas molecules, such as methane, trapping them and storing them. Such solids occur naturally on the ocean floor. The hope is that someday carbon dioxide can be trapped in a similar way.

Black Smoker and Hot Vent Creatures

http://www.youtube.com/watch?v=huTJlHMR_LE

http://ocean.si.edu/ocean-videos/hydrothermal-vent-creatures