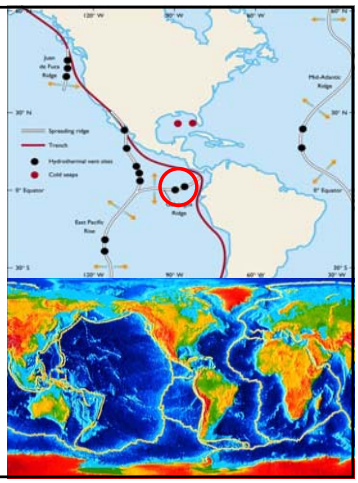
EOSC 112

Hydrothermal vents

Discovery: first discovered in 1977 at 2500m depth at Galapagoss rift and represented an example of an alternative ecosystem supported by chemosynthetic primary production

Distribution: mid-ocean ridges with low rates of sea floor spreading. HV are likely to be found at any number of sites of active volcanic activity

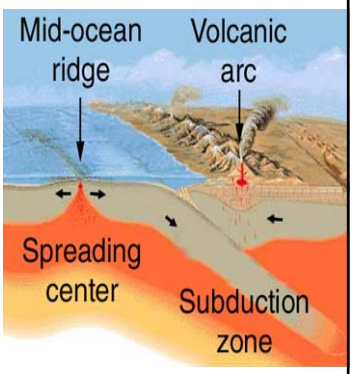


EOSC 112: hydrothermal vents

Hydrothermal vents: geysers on the seafloor, hot fluid spilled out of chimneys

- black smokers (iron & sulfide)
- white smokers (barium, calcium, silicon)

Cold seeps: similar to hydrothermal vents but seep waters that are about the same temperature as the surrounding waters



EOSC 112: hydrothermal vents

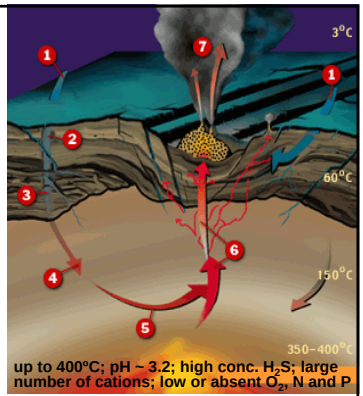
(1) Cold seawater sinks down trough cracks in the crust

(2) Oxygen and potassium are removed from the seawater and it becomes acidic

(3) Calcium, sulfate and magnesium are removed from fluid

(4) As water heats up, it reacts with the rocks and picks up sodium, sulfate and potassium from the surrounding crust

(5) The fluids reached their highest temperatures. Copper, zink, iron, and sulfur from the crust dissolve in the fluids

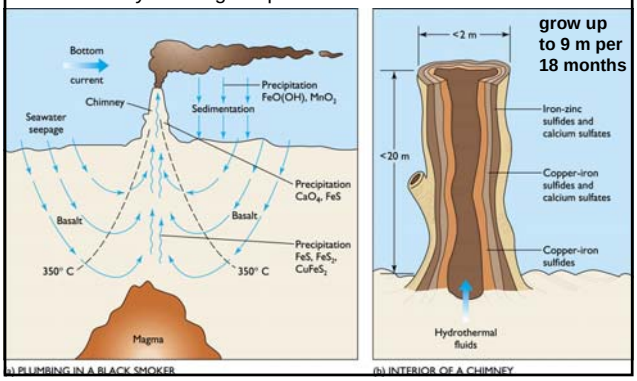


(6) Hot fluids carrying dissolved metals rise up trough the crust

(7) The hydrothermal fluid mix with cold, oxygen-rich seawater. Metal and sulfur combine to form black, metal-sulfide minerals

EOSC 112: hydrothermal vents

Chimneys top some hydrothermal vents and formed from dissolved metals that precipitate out when super-hot vent water meets nearly freezing deep ocean water



Chemosynthesis: fixation of inorganic carbon into organic compounds using energy from chemical reaction (oxidation) rather than from sunlight (photosynthesis)

$$CO_2 + H_2S + O_2 + H_2O \rightarrow \underset{\text{carbohydrate}}{CH_2O} + H_2SO_4$$

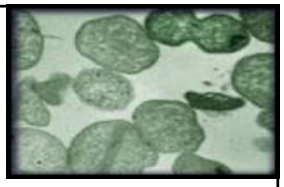
The sources of energy for primary production are reduced inorganic substances in the hydrothermal fluid

Free energy of chemolithotrophic oxidation reactions

Reaction	Standard free energy, kJ/mol
$H_2 + ½O_2 = H_2O$	-237
$2H_2 + CO_2 = CH_4 + 2H_2O$	-35
$NH_4^+ + 1½O_2 = NO_2^- + H_2O + 2H^+$	-272
$NO_2^- + ½O_2 = NO_3^-$	-73
$H_2S + ½O_2 = S^0 + H_2O$	-210
$HS^- + 2O_2 = SO_4^{2-} + H^+$	**-716**
$S^0 + 1½O_2 + H_2O = H_2SO_4$	**-496**
$S_2O_3^{2-} + 2O_2 + H_2O = 2SO_4^{2-} + 2H^+$	**-936**
$2F^{2+} + 2H^+ + ½O_2 = 2Fe^{3+} + H_2O$	-47
$Mn^{2+} + H_2O + ½O_2 = MnO_2 + 2H^+$	-67

Oases on the seafloor

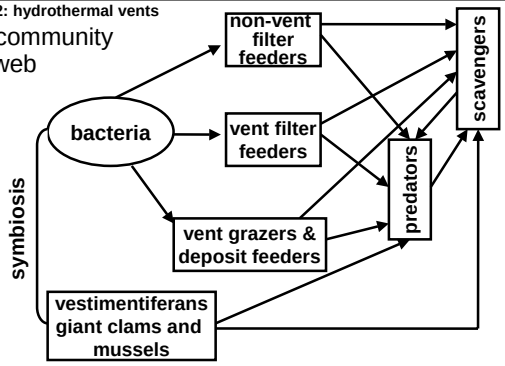
Bacteria form the base of the trophic structure at vent communities



Four major trophic pathways in vent communities

- bacteria expelled in the emergent plume of a vent are dispersed over large distances becoming prey to not-vent filter feeders;
- vent filter feeders feed almost exclusively on expelled bacteria;
- vent grazers feed on the microbial mats commonly found around chimneys;
- many sessile macro-invertebrates developed a symbiotic association with chemosynthetic bacteria

Vent community food web

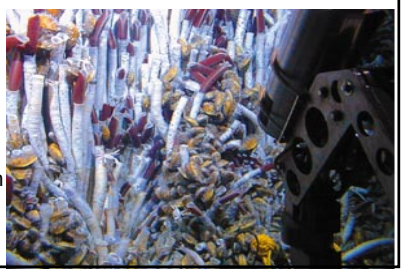


Vent communities are small, *ca* 25-60 m in diameter. Ephemeral. Low diverse but highly endemic communities. Out 236 described vent species, 223 (~ 95%) are new to science

EOSC 112: hydrothermal vents

Tube worms (vestimentiferans): *Riftia* tube worms are encased in leathery tubes, with only a plume of many tentacle-like gill filaments protruding from the open end.
Tube worms lack a mouth or digestive tract but still free living and not parasitic. They posses a special internal organ, trophosome, witch contain symbiotic bacteria (up to 60% of *Riftia* dry mass)

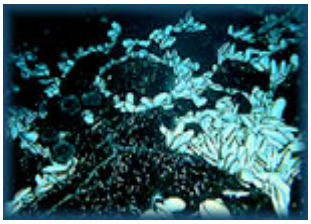
Tube worms may measure 1.5 m long and 20 to 40 mm in diameter. Their tubes may be as long as 3 m
Densities: up to 176 ind.m^{-2} or 9 kg.m^{-2}



EOSC 112: hydrothermal vents

Bathymodiolid Mussels: filter feeders, also posses a symbiotic bacteria, which enables them to survive farther from the direct sources of vent water

Vescomyid Clams: retain some ability to filter-feed but like tube worms rely heavily on their bacterial symbionts that live within their gills.
Reach size of 30-40 cm



EOSC 112: hydrothermal vents

Vent shrimps: in densities of up to 1500 m^{-2}, often surround smoking vents and feed on bacterial mats

Spider crabs:
mainly scavengers

EOSC 112: hydrothermal vents

Total biomass of vent community can exceed 20-30 kg.m^{-2}. Yet it is very localized and short living, often ephemeral community.
Vent community may persist from years to decades but < 100 yr

<u>Animals developed unique adaptations</u>:

- resistance to high temperatures and large variations in salinity and oxygen;
- resistance to high concentrations of sulfur and other inorganic substances;
- grow rapidly to sexual maturity and generally gigantic;
- produce many offspring;
- obviously have efficient means of dispersal