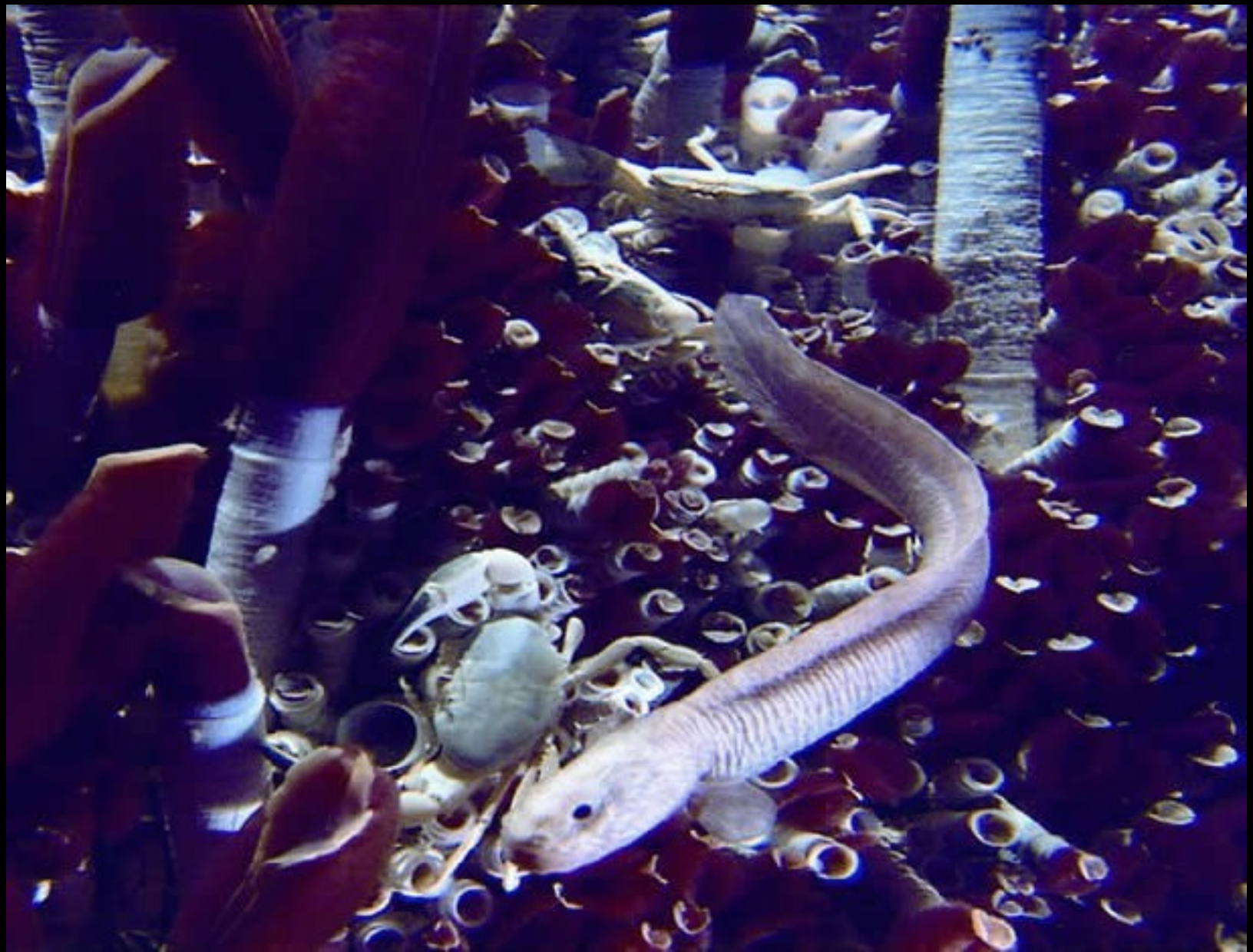
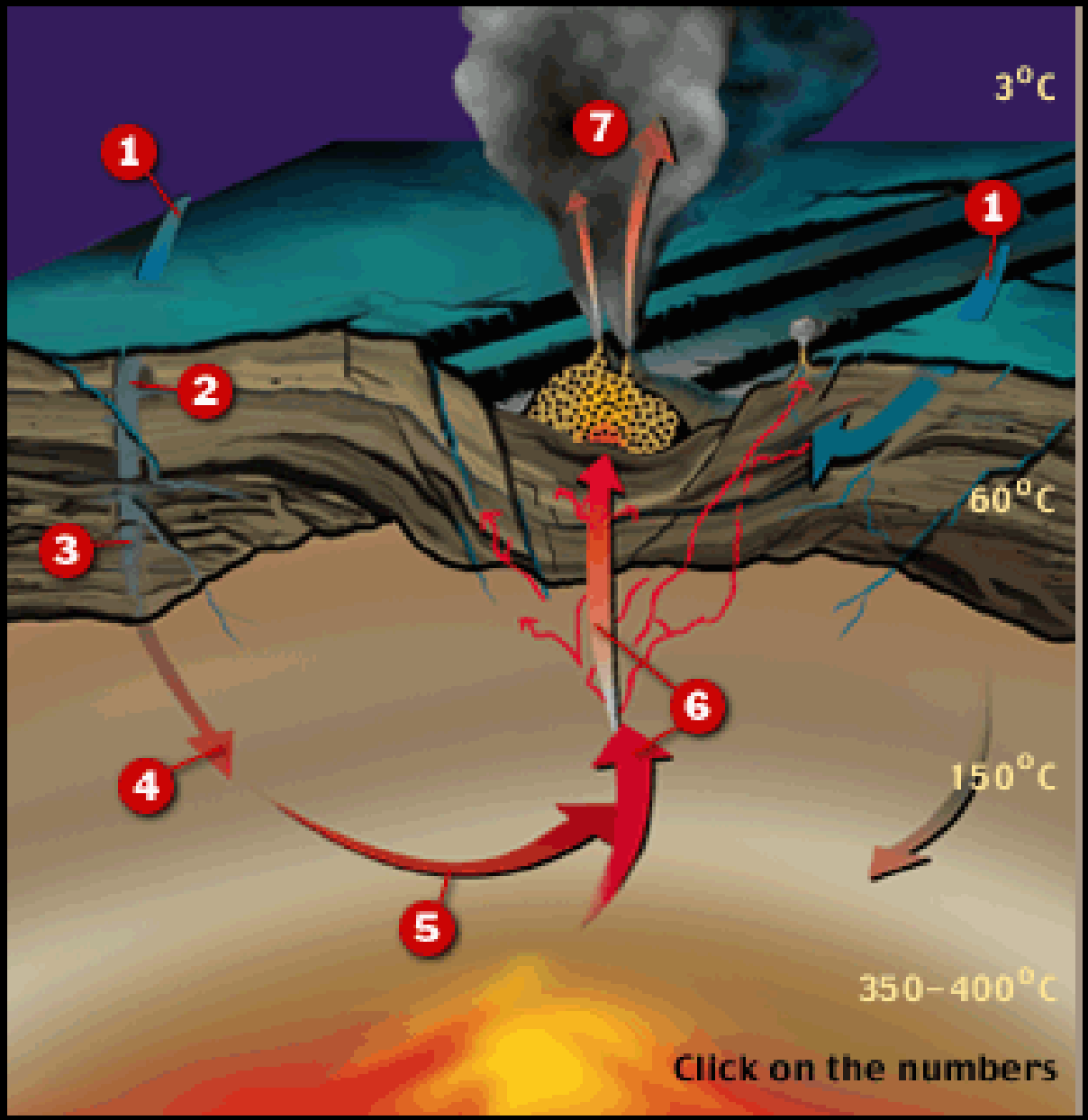
Hydrothermal Vent Communities

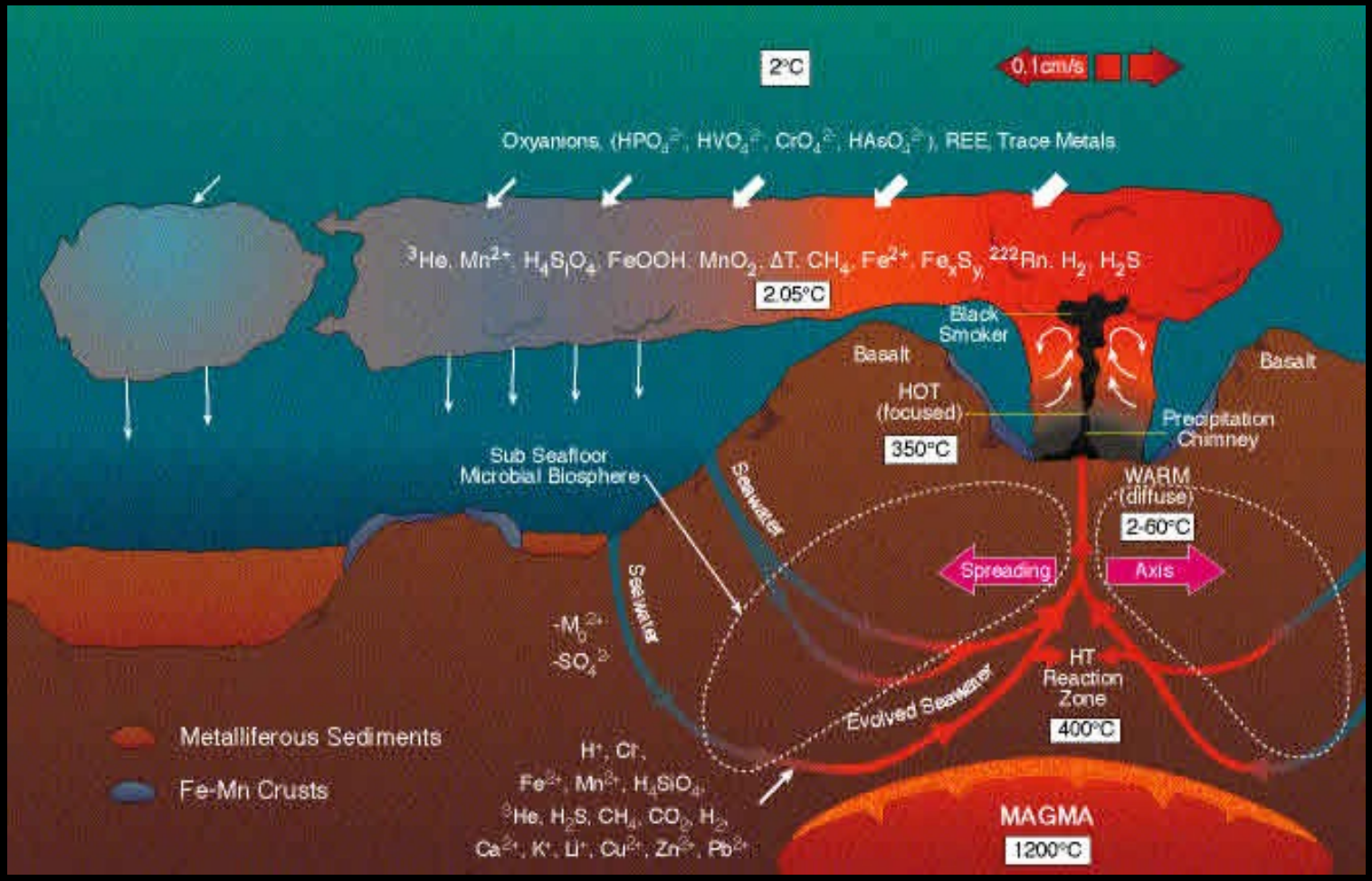


Hydrothermal vent discovery-1977


3°C
1
7
1
2
60°C
3
6
4
150°C
5
350-400°C
Click on the numbers

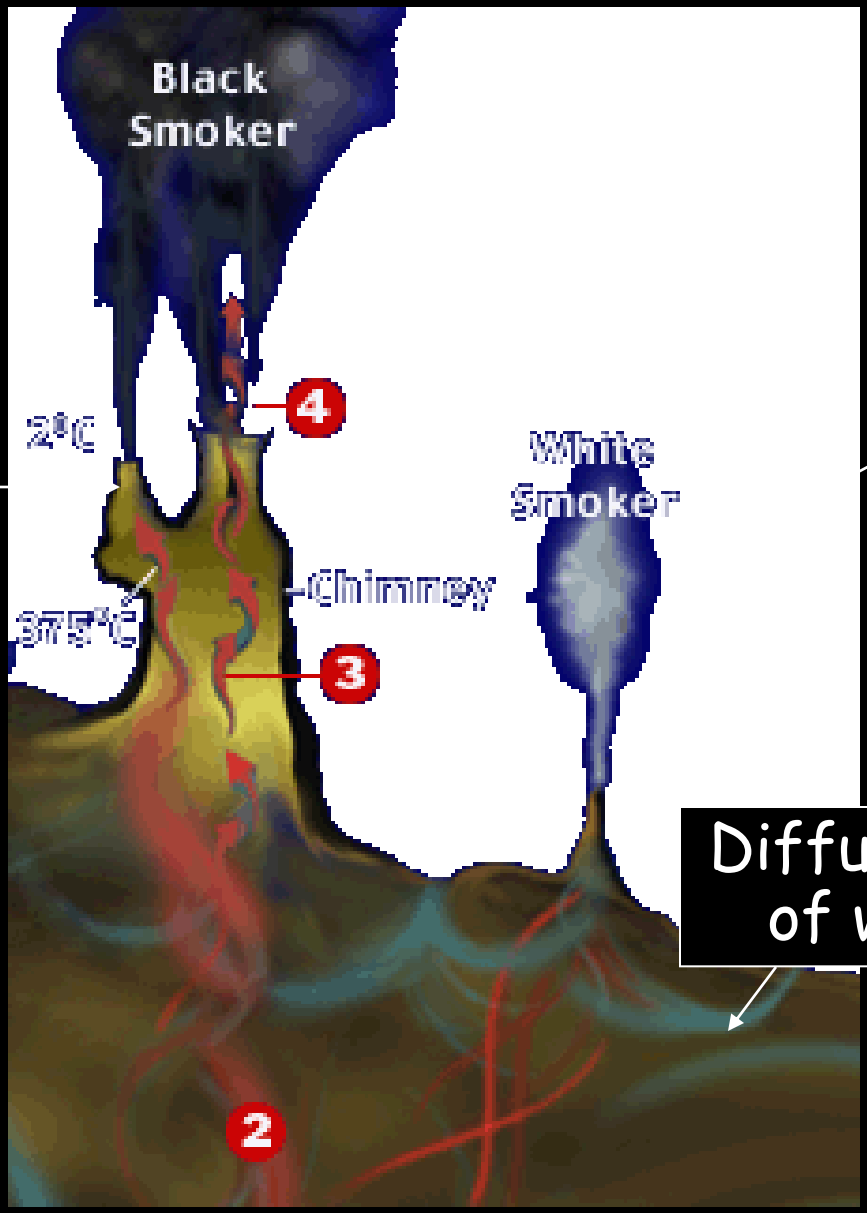
Hydrothermal Vents

1. Cold seawater sinks down through the crust.
2. O_2 and K are removed from the seawater.
3. Ca, SO_4, and Mg are removed from the fluid.
4. Na, Ca, and K from the crust enter the fluid.
5. Highest temperatures (350-400 ^oC), Cu, Zn, Fe, and H_2S from the crust dissolve in the fluids.
6. Hot & acidic fluids with dissolved metals rise up through crust.
7. The hydrothermal fluids mix with cold, O_2-rich seawater. Metals and sulfur combine to form metal-sulfide minerals: MnO_2, $FeO(OH)$, …



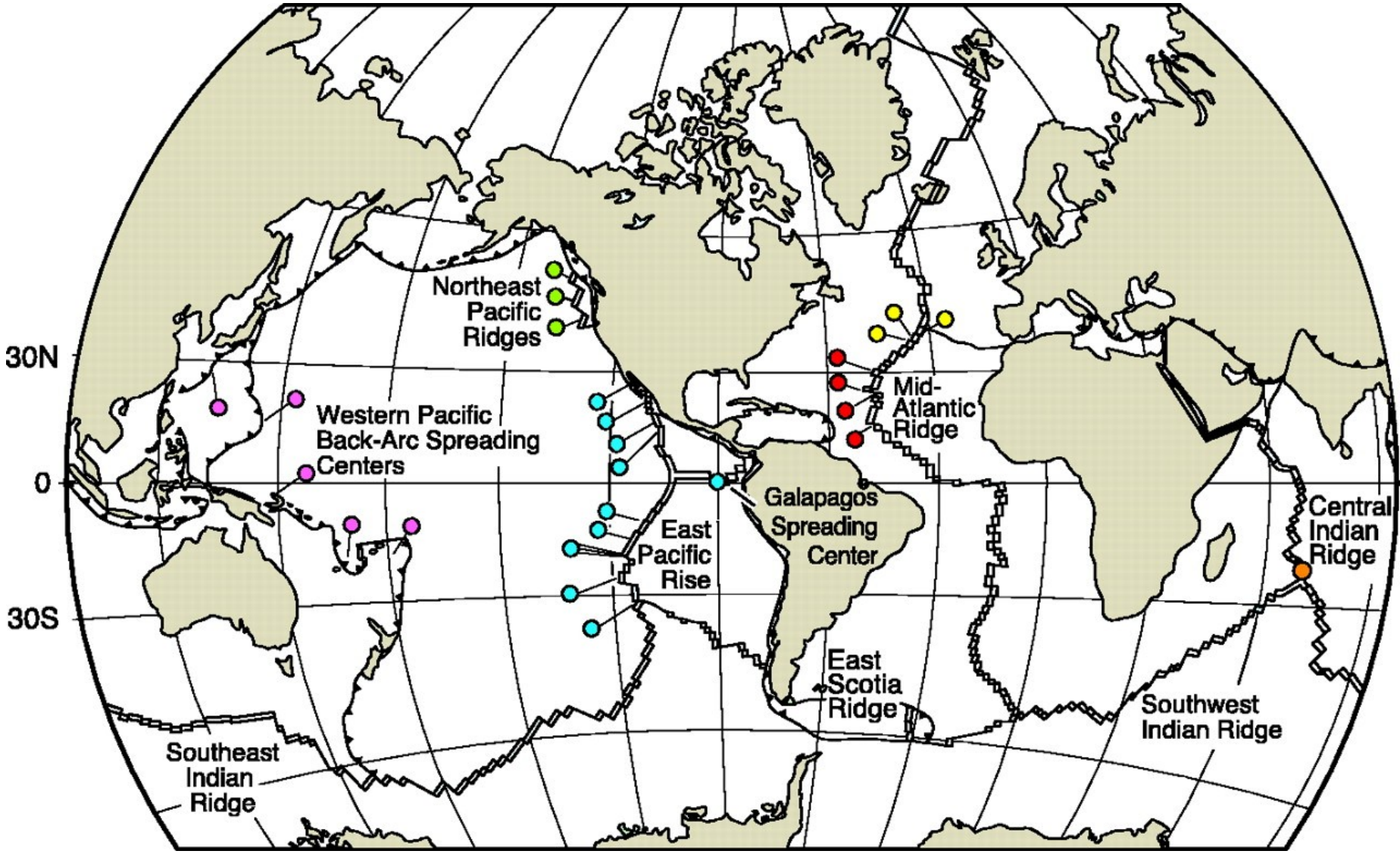
www.pmel.noaa.gov/vents

Black & White smokers



Smoker chimney section

Hydrothermal Vent Distribution



Pink, western Pacific; green, northeast Pacific; blue, East Pacific Rise; yellow, Azores; red, Mid-Atlantic Ridge; orange, Indian Ocean


Juan de Fuca
Broken Spur
Menez Gwen
Marianas Trough
Guaymas Basin
Lucky Strike
Logatchev
21°N EPR
TAG
13°N EPR
Snake Pit
9-10°N EPR
Edmond
Galapagos
17-20°S EPR
Kairei

Hydrothermal vent age estimates

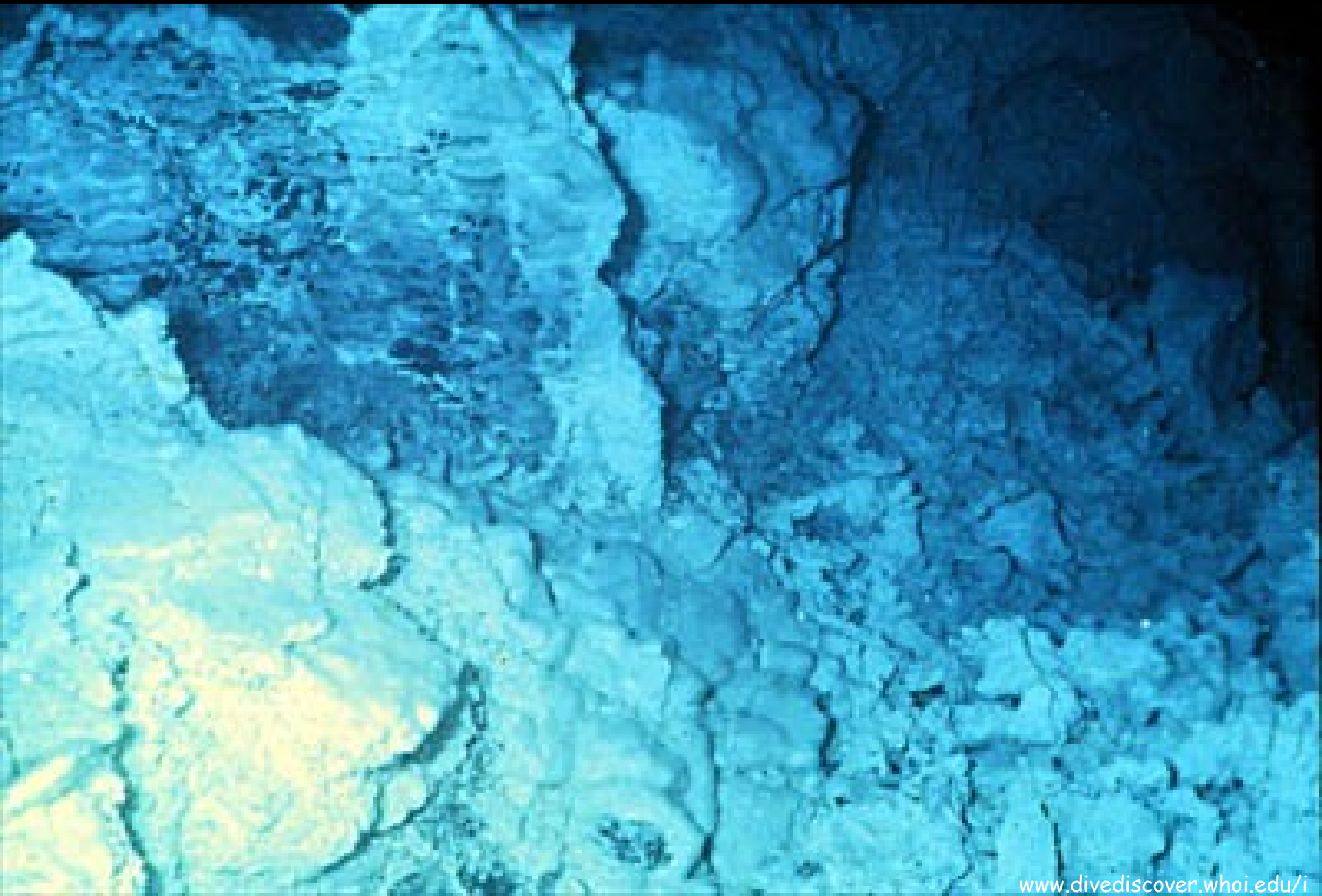
Age	**Technique**
• 20-100 years	• sulfide dating
• Decades	• mollusk shells
• <10 years	• heat loss
• < 6 months	• submersible observations

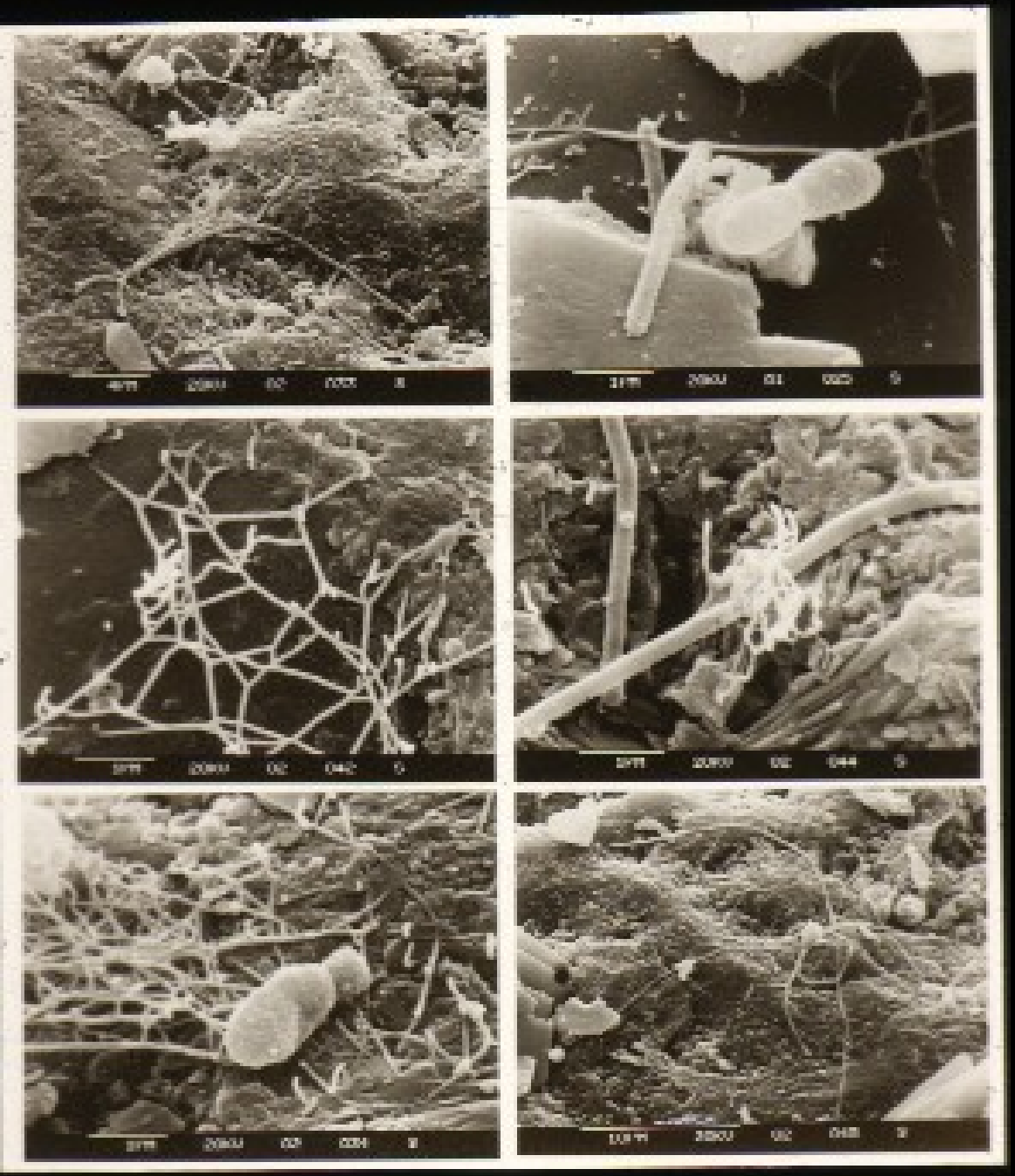
Hydrothermal energy source

$$H_2S + O_2 \rightarrow SO_{4\ +} + H^+ + ATP$$

- Chemosynthetic (sulfur oxidizing)
- Thermophilic Bacteria (up to 120°C)
- Hot, anoxic, sulfide rich water mixes with Cold oxygenated water
- Hydrothermal Vents as origin of Life?

Bacterial mat





Bacteria from 120°C

http://mollie.berkeley.edu/~volkman/

Vent biological communities

- BACTERIA (Bacteria and Archea)
- 400 morphological invertebrate species
  - New species every 2 weeks during 25 years!
- Evolutionary Origin
  - Derived from surrounding Deep Sea
  - Derived from Shallow Water species
  - Many evolutionary radiations at species level
  - Many vent taxa originated at other organically enriched environments (cold seeps and whale bones)
- Vents as stable refugia from Global extinctions

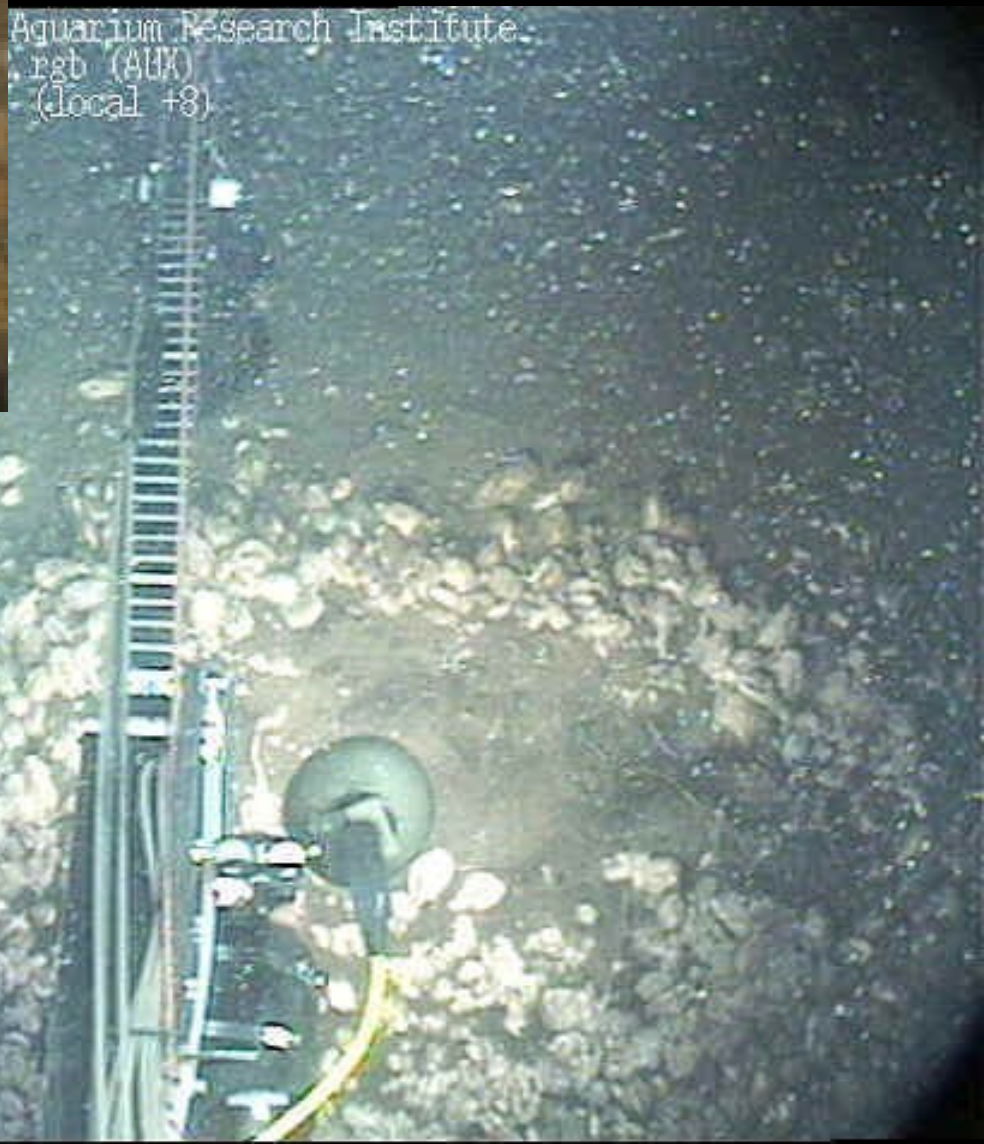
Cold Seeps

$$CH_4 + O_2 \rightarrow CO_2 + H_20 + ATP$$

$$CH_4 \rightarrow CH3^- + H^+ + ATP$$

$$H_2S + O_2 \rightarrow SO_{4\ +} + H^+ + ATP$$

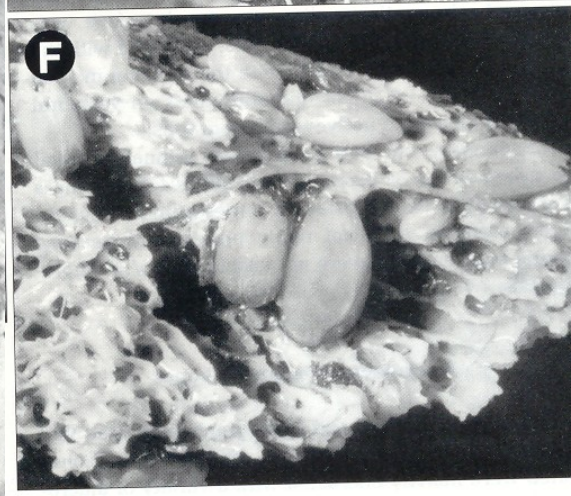
- Hydrocarbon reservoirs
- "methane bubbling"
- Continental shelves and Trenches
- 200 invertebrate species


Aquarium Research Institute
rgb (AUX)
(local +8)

Whale skeletons & sunken logs

$H_2S + O_2 \rightarrow SO_{4\,+} + H^+ + ATP$

- Osteophiles
- Potential 'stepping stones' for certain invertebrate vent species



Invertebrate food sources

Food chain based on sulfur-oxidizing bacteria

- Symbiosis with Bacteria
  - Vestimentiferan tube worms
  - Vent Mussels and vent clams
- Ingestion of Bacteria
  - Grazers (gastropod limpets and snails)
  - Filter Feeders (vent shrimp, polychaete worms, amphipods, anemones)
- Predators
  - Ventfish, octopus
- Scavengers
  - Crabs

Oceanic vent Biogeography

Atlantic vents

- Vent shrimp

Indian vents

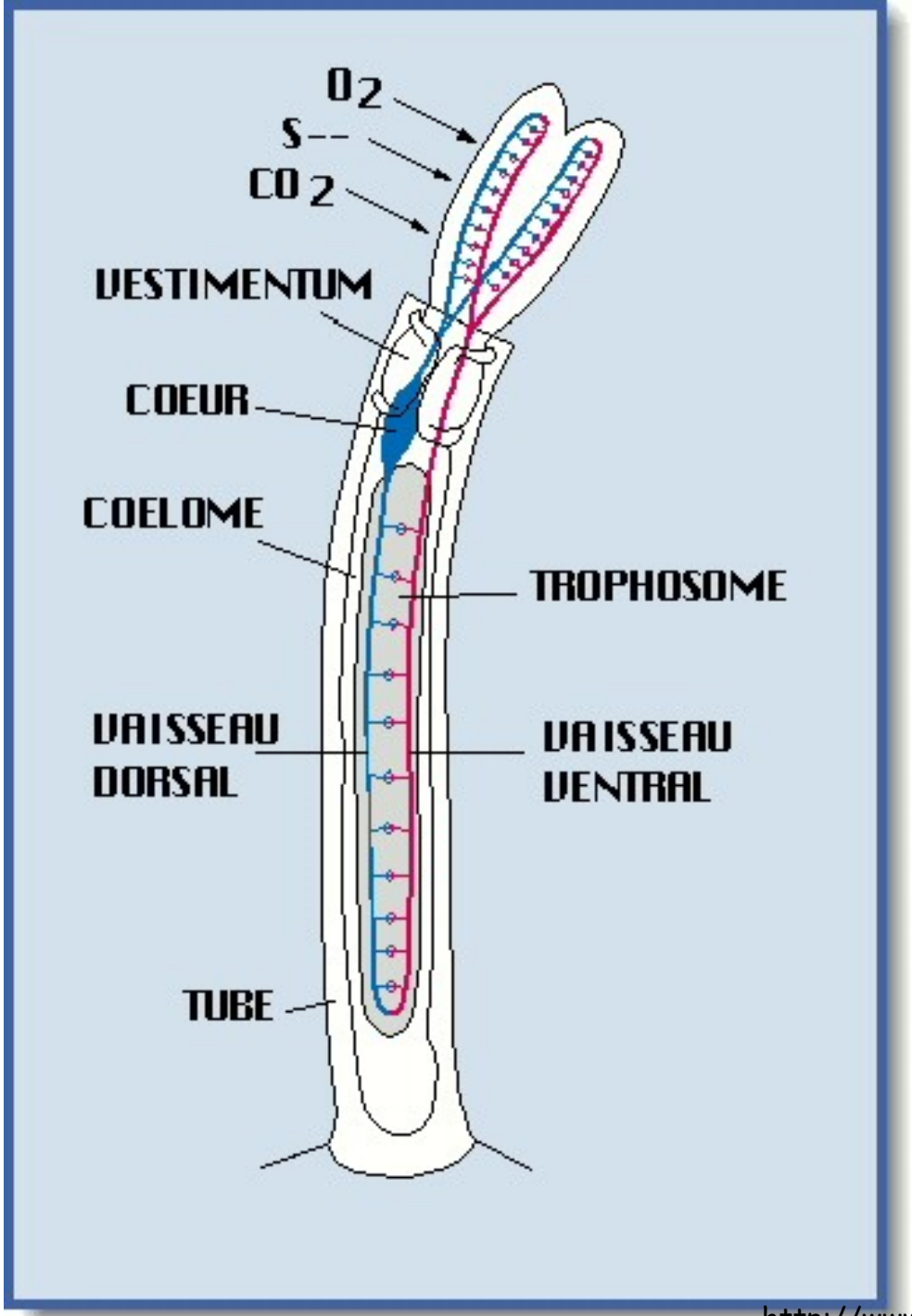
- Vent shrimp
- Anemones
- Pacific vent species

East Pacific vents

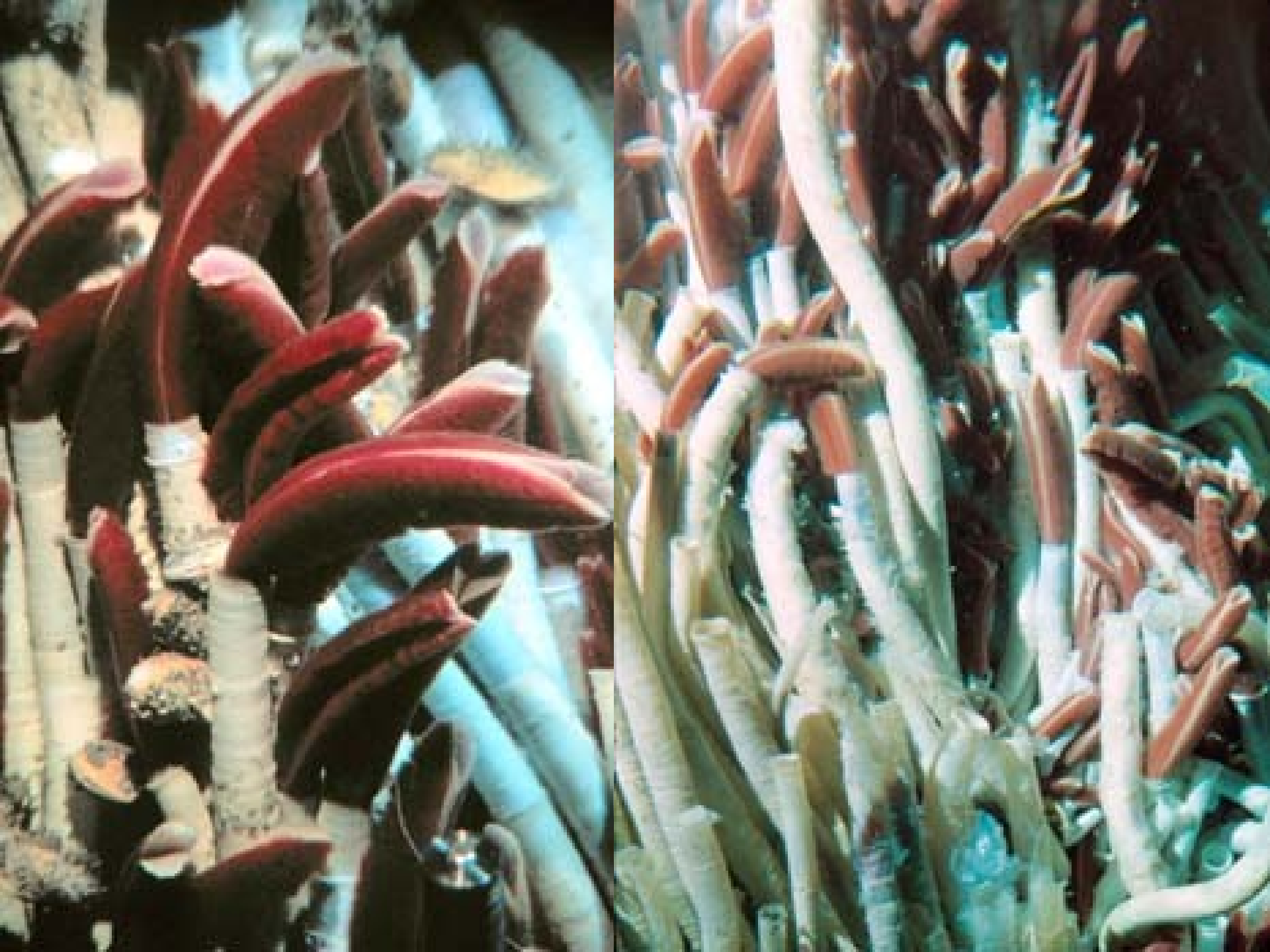
- Vestimentiferan worms
- Alvinellid polychaetes

Vestimentiferan worms

http://web.uvic.ca/%7Everenat/364-13.jpg



http://www.ifremer.fr/droep/Driftia.html



Vent Mussels (*Bathymodiolus*)

www.divediscover.whoi.edu/i

Vent Clams (*Calyptogena*)

Vent Shrimp (Bresiliidae)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Alvinellid worms

Vent limpets

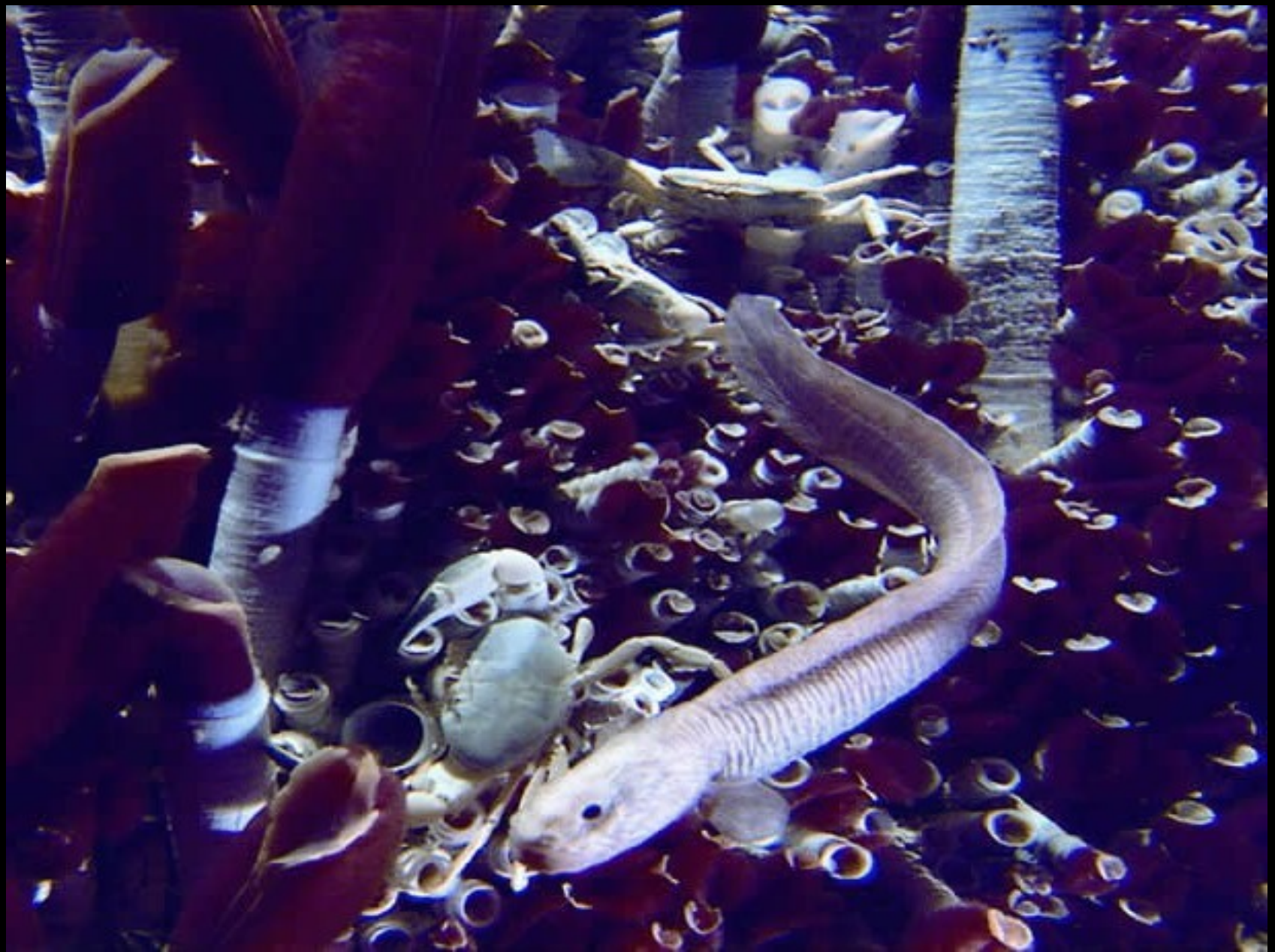
http://web.uvic.ca/~abates/


www.divediscover.whoi.edu/i


1cm
www.senckenberg.uni-frankfurt.de/

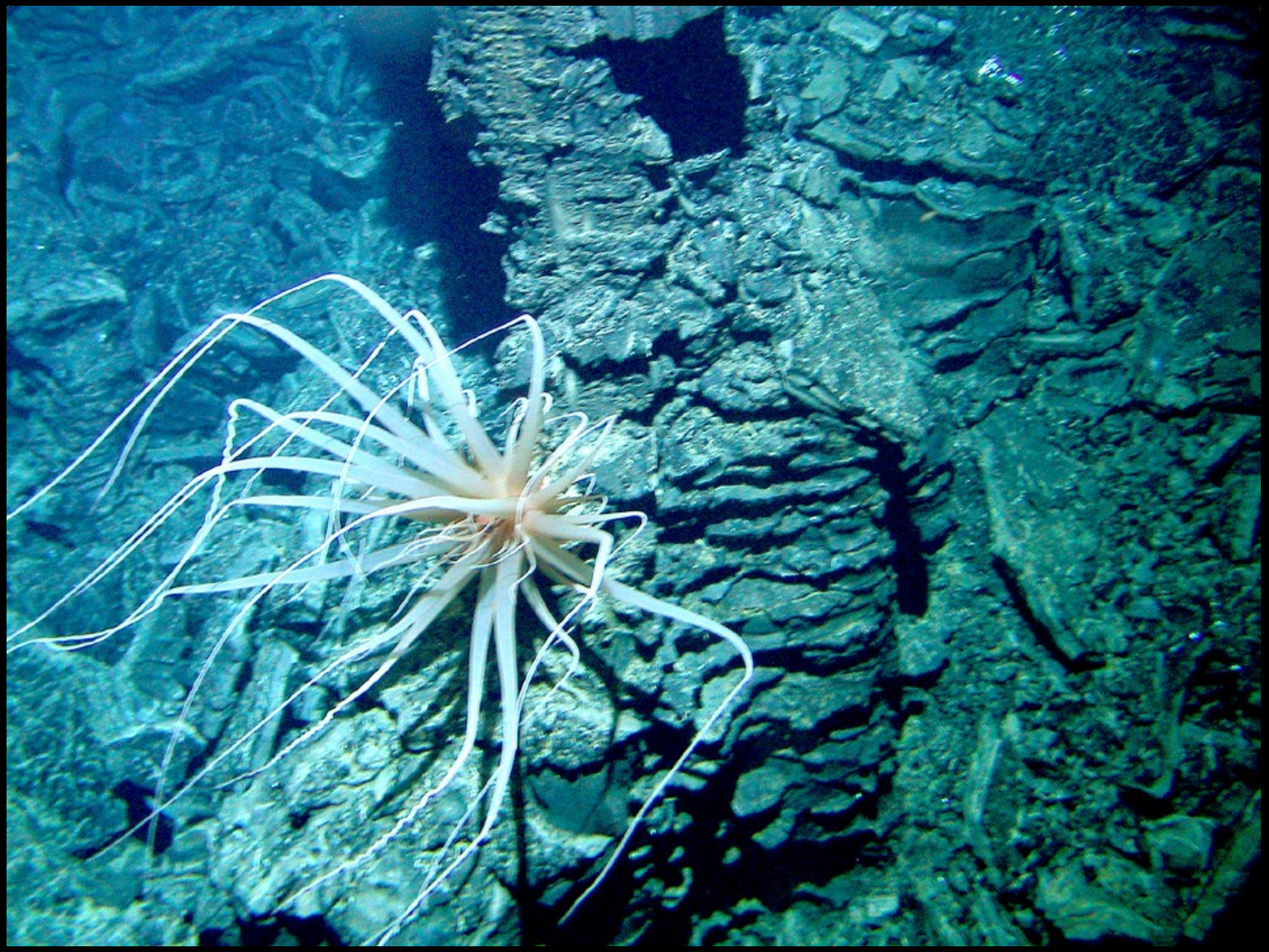
Vent Crabs

Ventfish (*Thermarces cerberus*)

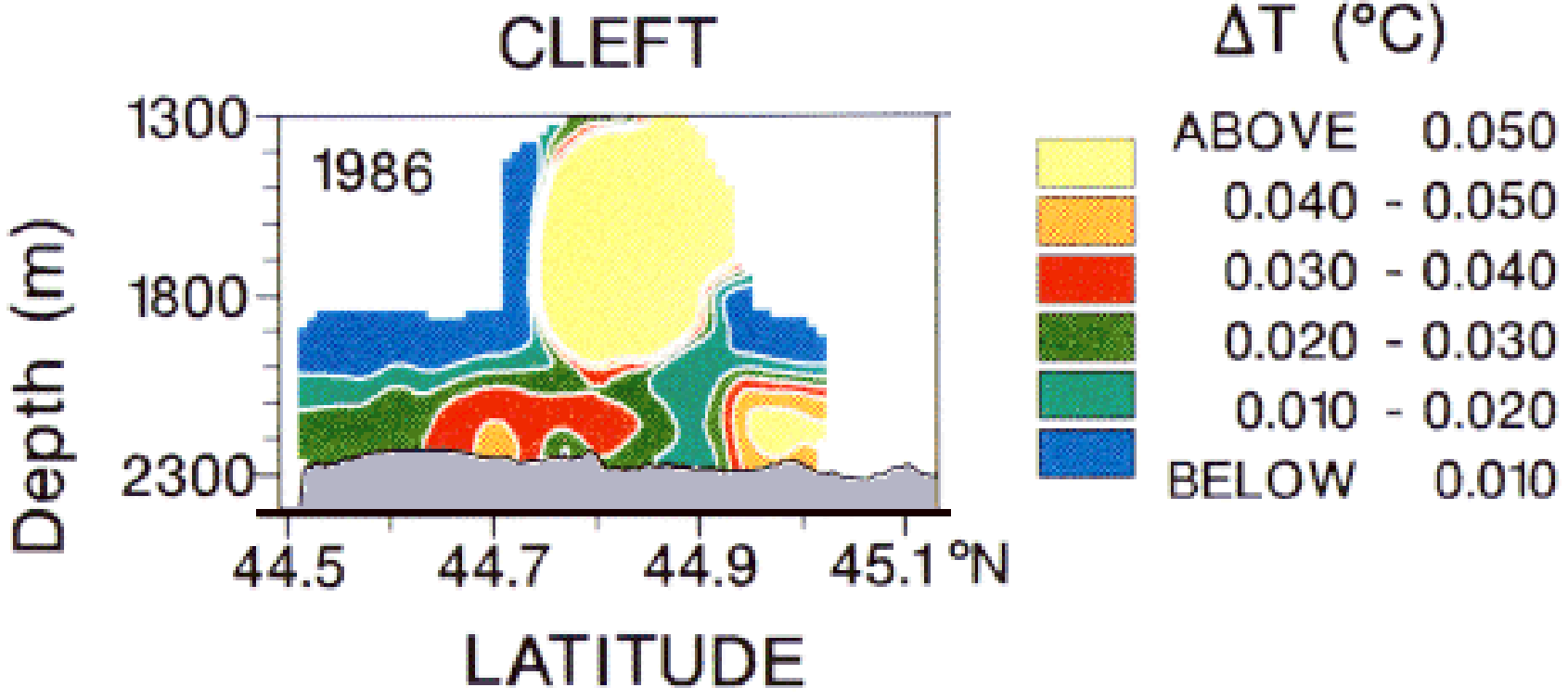



www.divediscover.whoi.edu/i

Periferic filter feeders



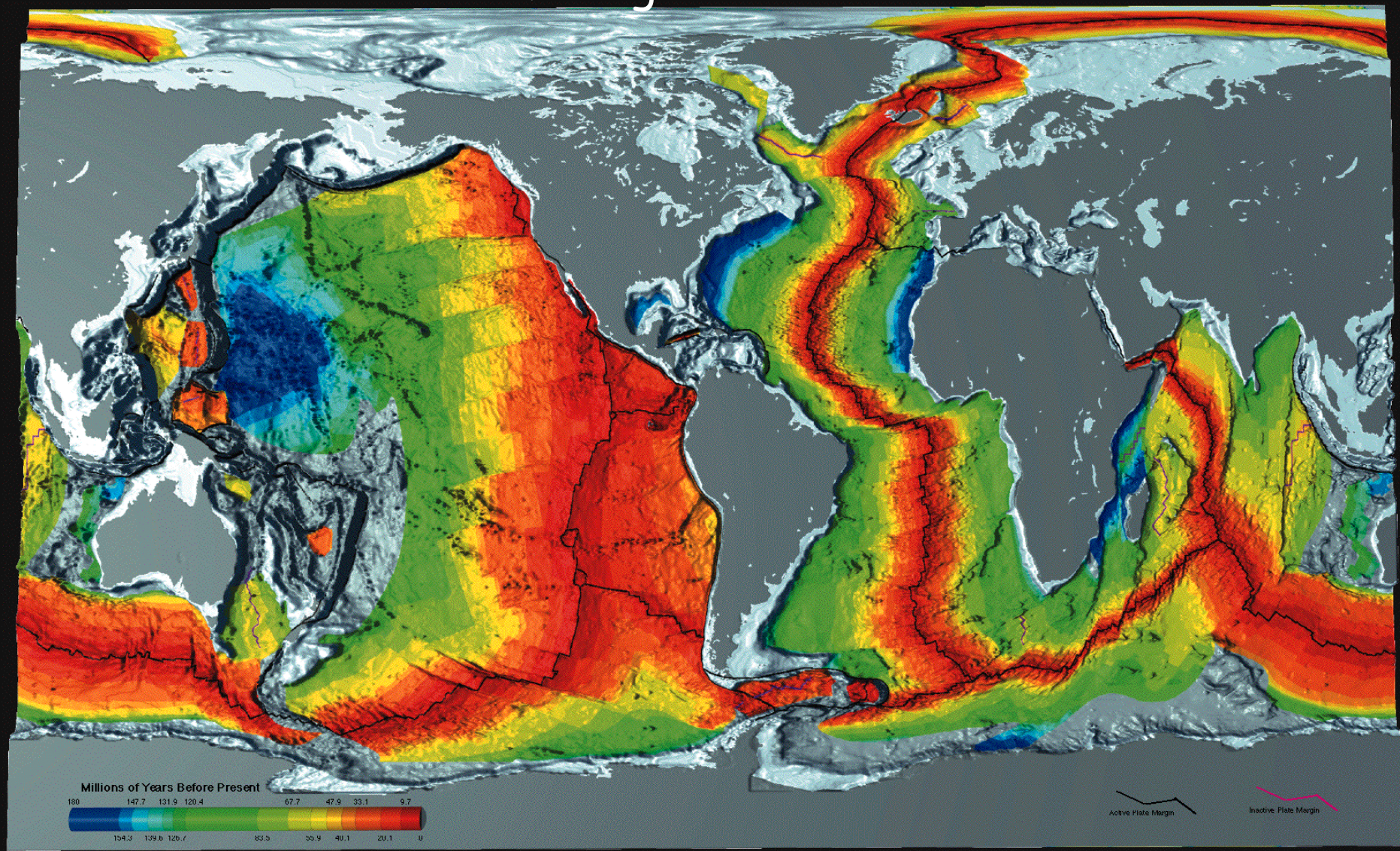
Larval dispersal between vents
Vent Plumes



www.pmel.noaa.gov/vents/PlumeStudies

Tubeworm spawning

Ocean Crust Age



University of Sydney

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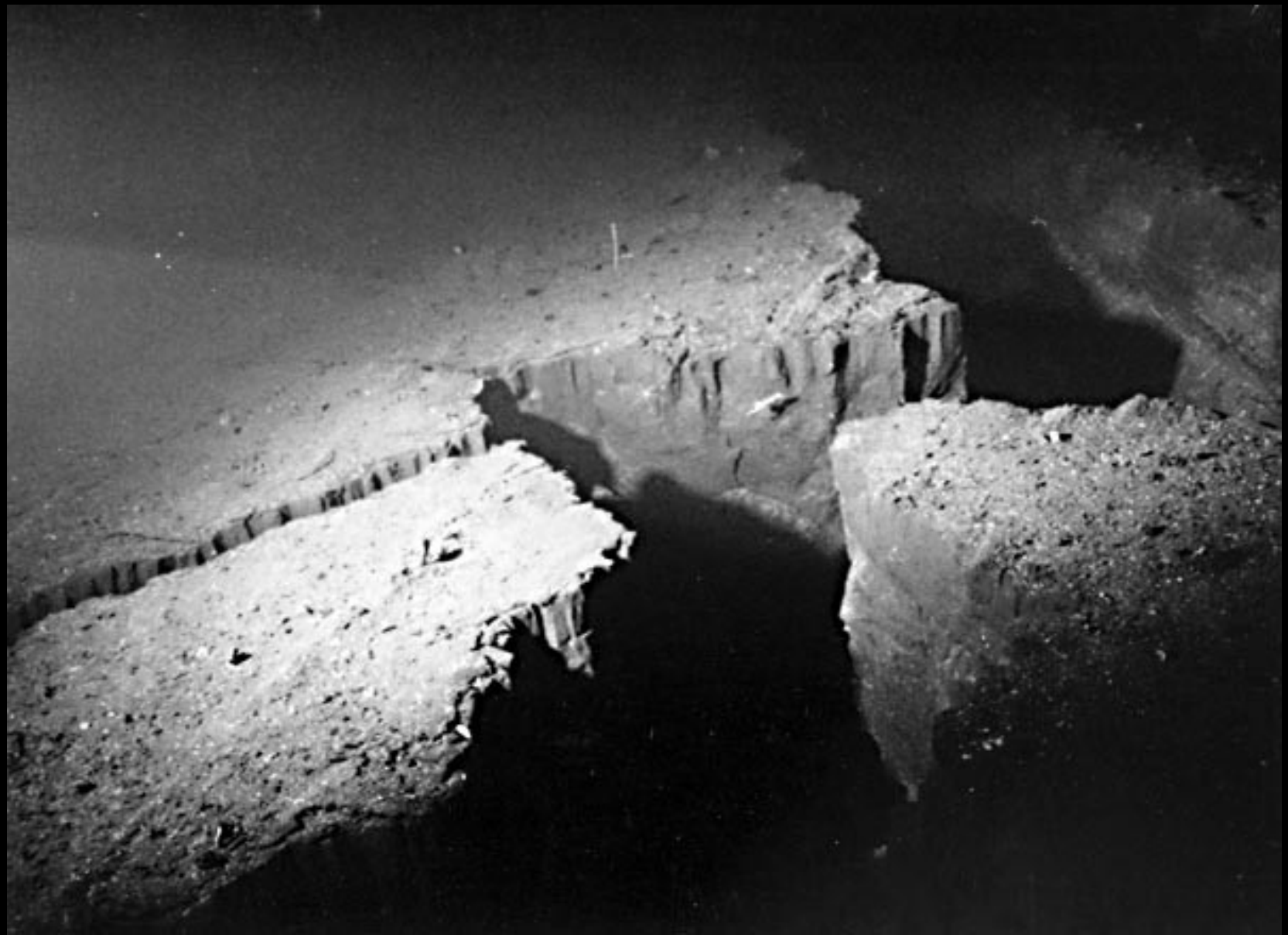
(e-mail: roest@agc.nrcan.gc.ca)

The color image representing crustal ages was created from a digital age grid of the ocean floor with a grid node interval of 0.1 degrees using a self-consistent set of global isochrons and associated plate reconstruction poles. The age at each grid node was determined by linear interpolation between adjacent isochrons in the direction of spreading. Ages for ocean floor between the oldest identified magnetic anomalies and continental crust were interpolated by estimating the ages of passive continental margin

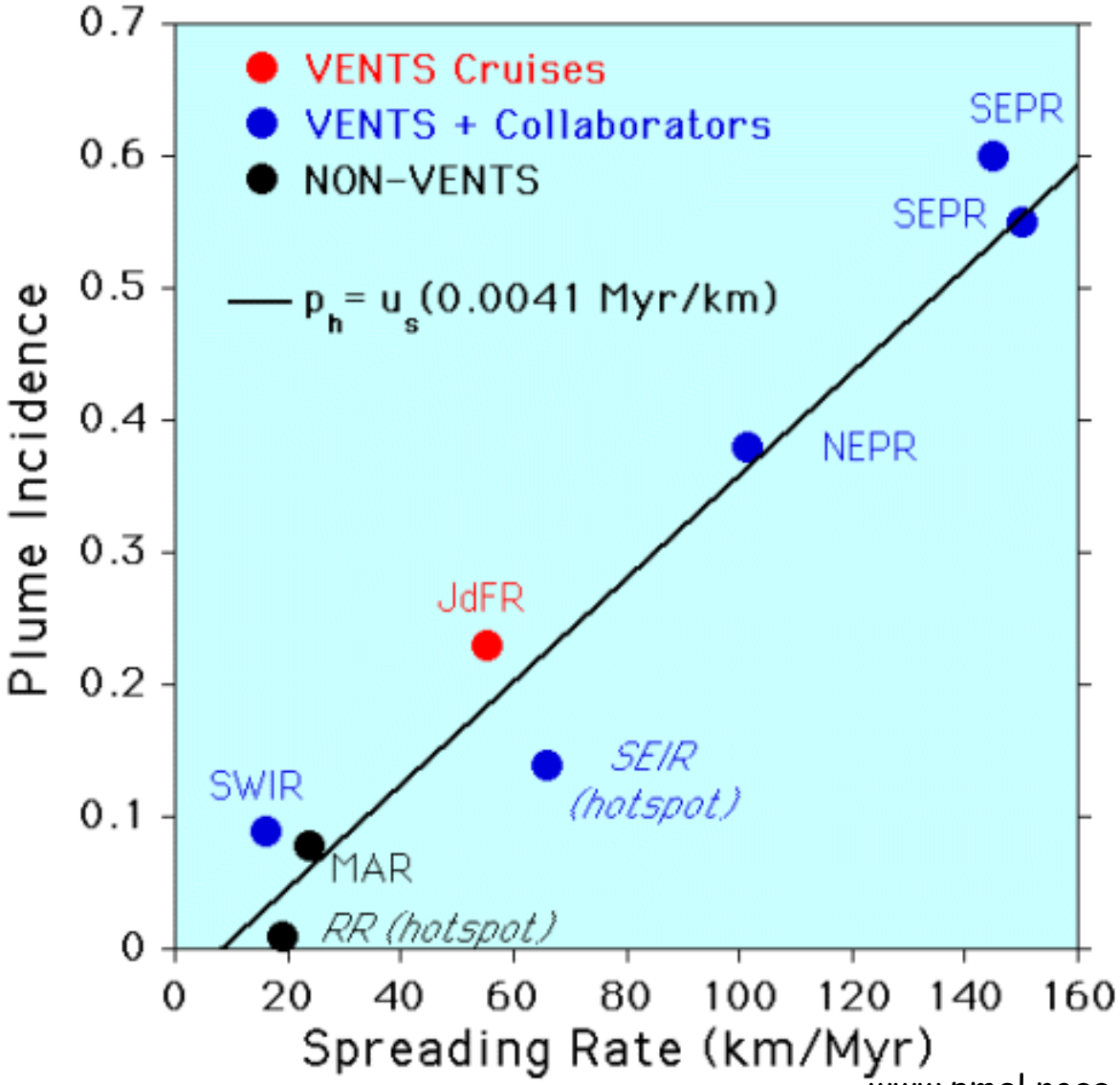
Mid Atlantic Ridge

http://faculty.washington.edu/lyn4/images/iceland.jpg

East Pacific Rise

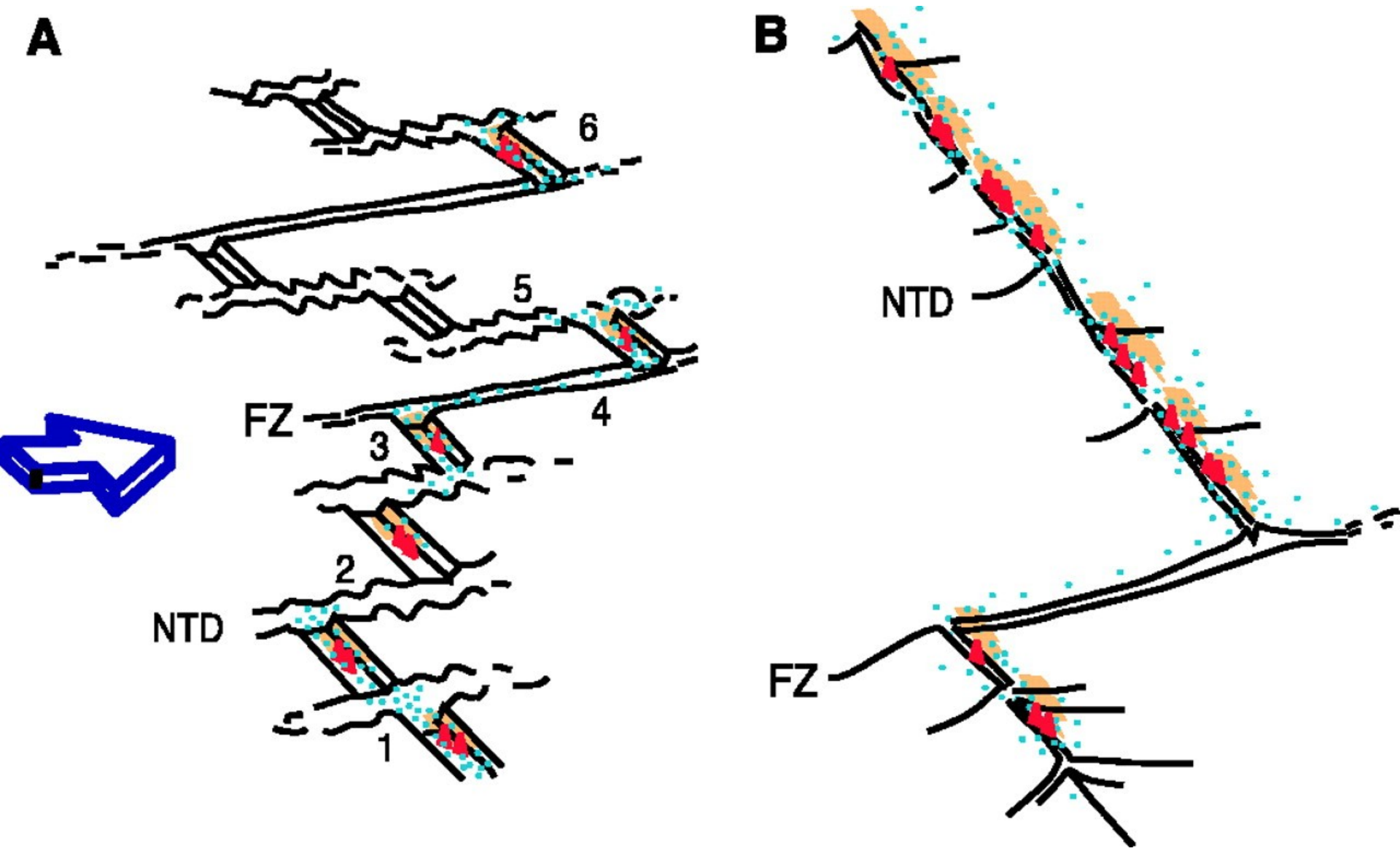


Spreading rate and Plume incidence



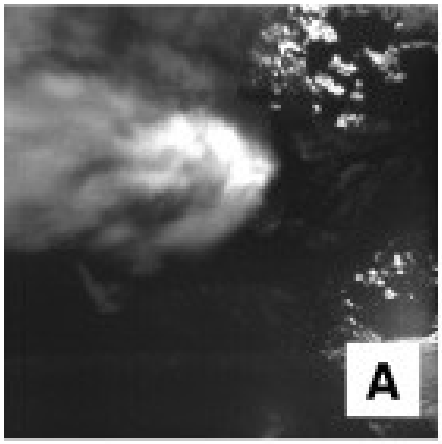
www.pmel.noaa.gov/vents/PlumeStudies

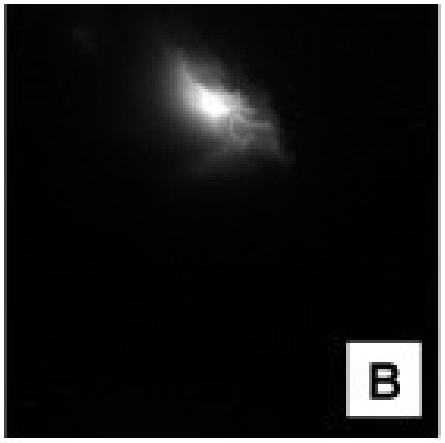
Fast and Slow spreading ridges

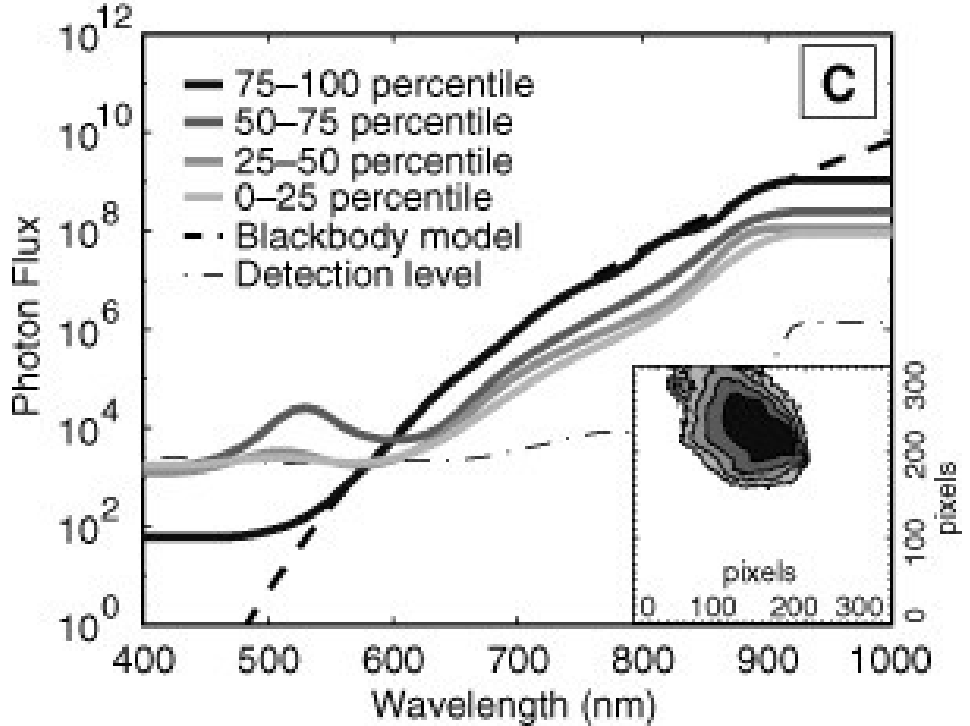


VanDover et al. 2002 (Science)

Electromagnetic emissions by vents







White et al. 2002

Light organs in vent organisms

www.deepsea.com/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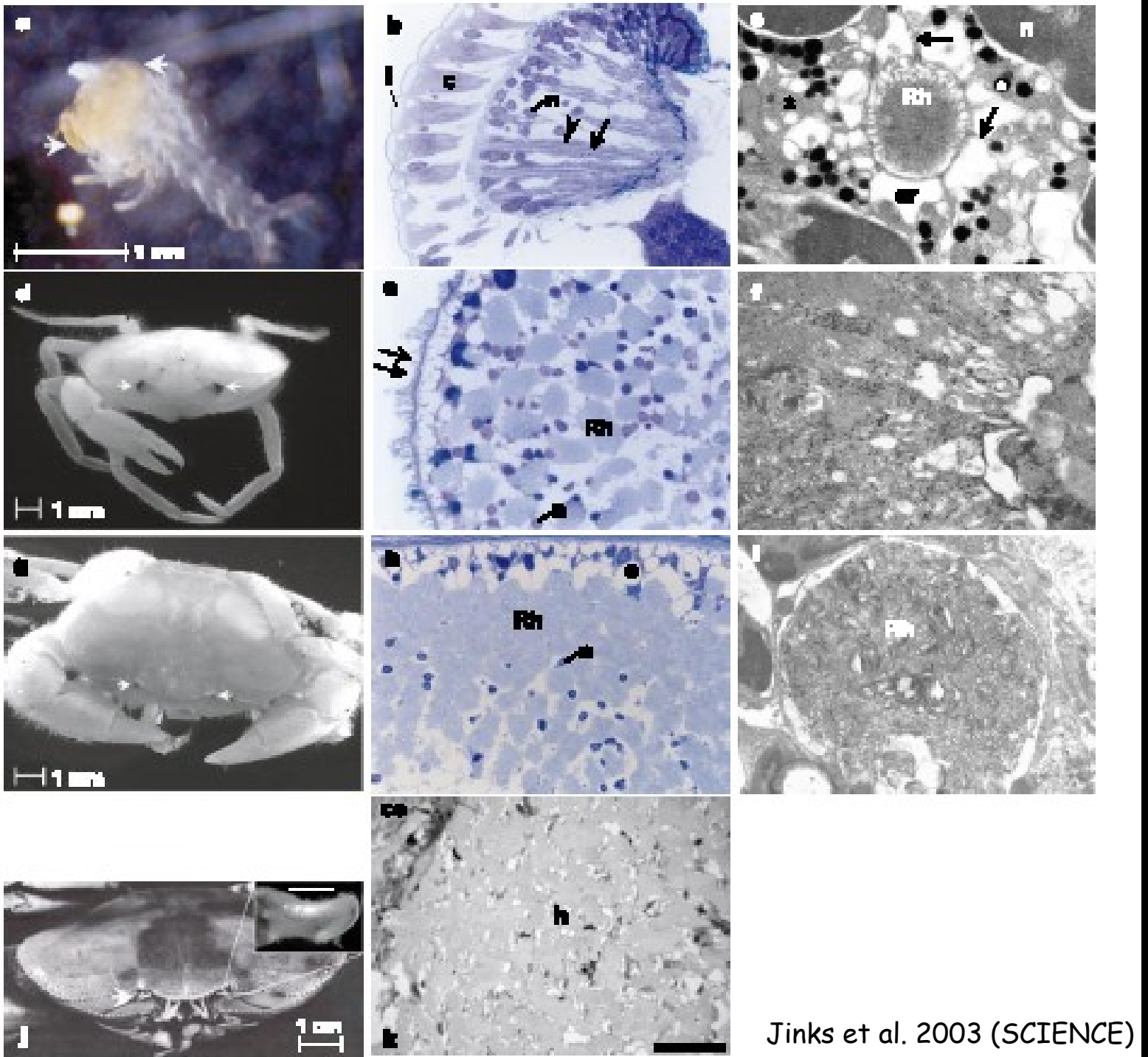
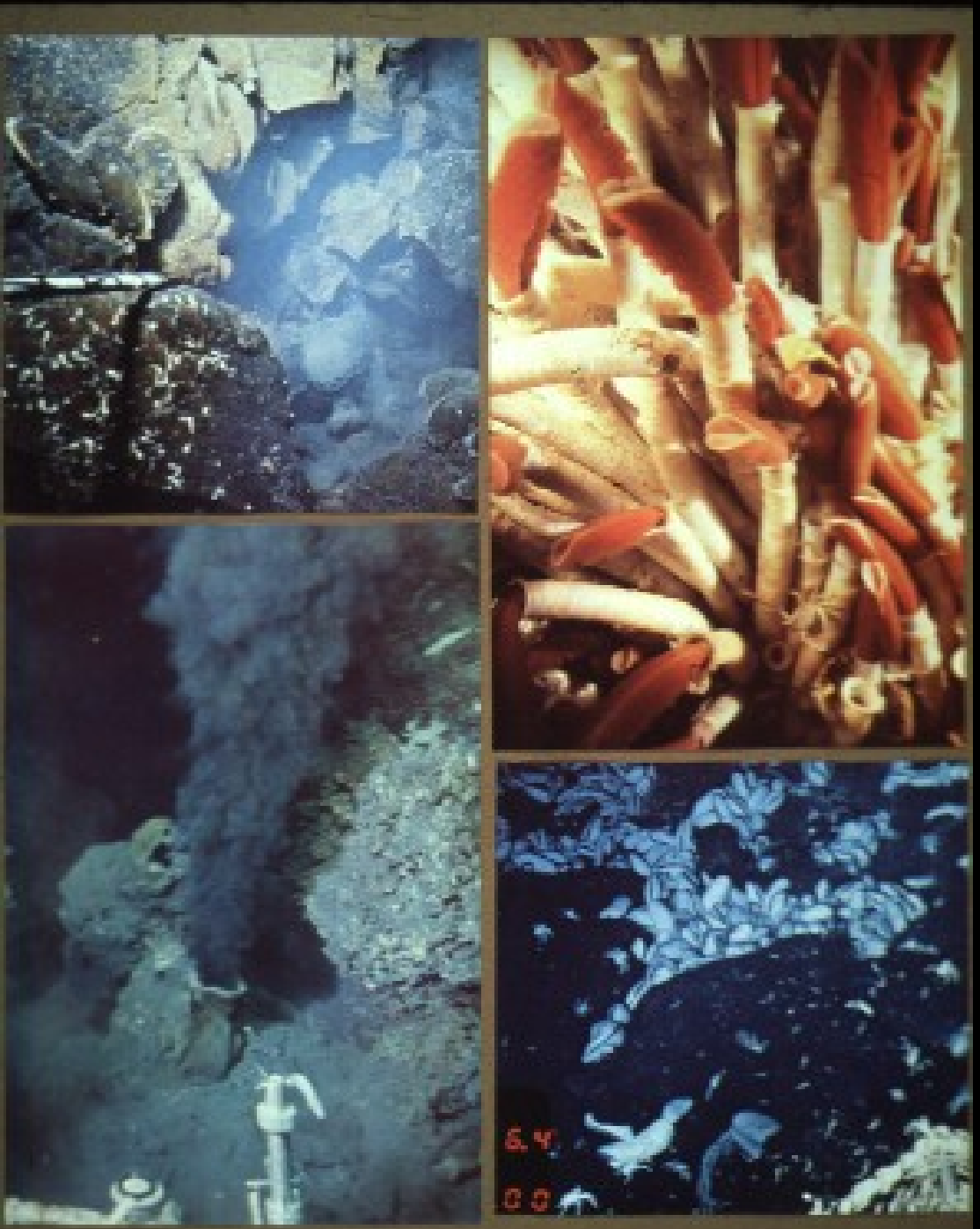


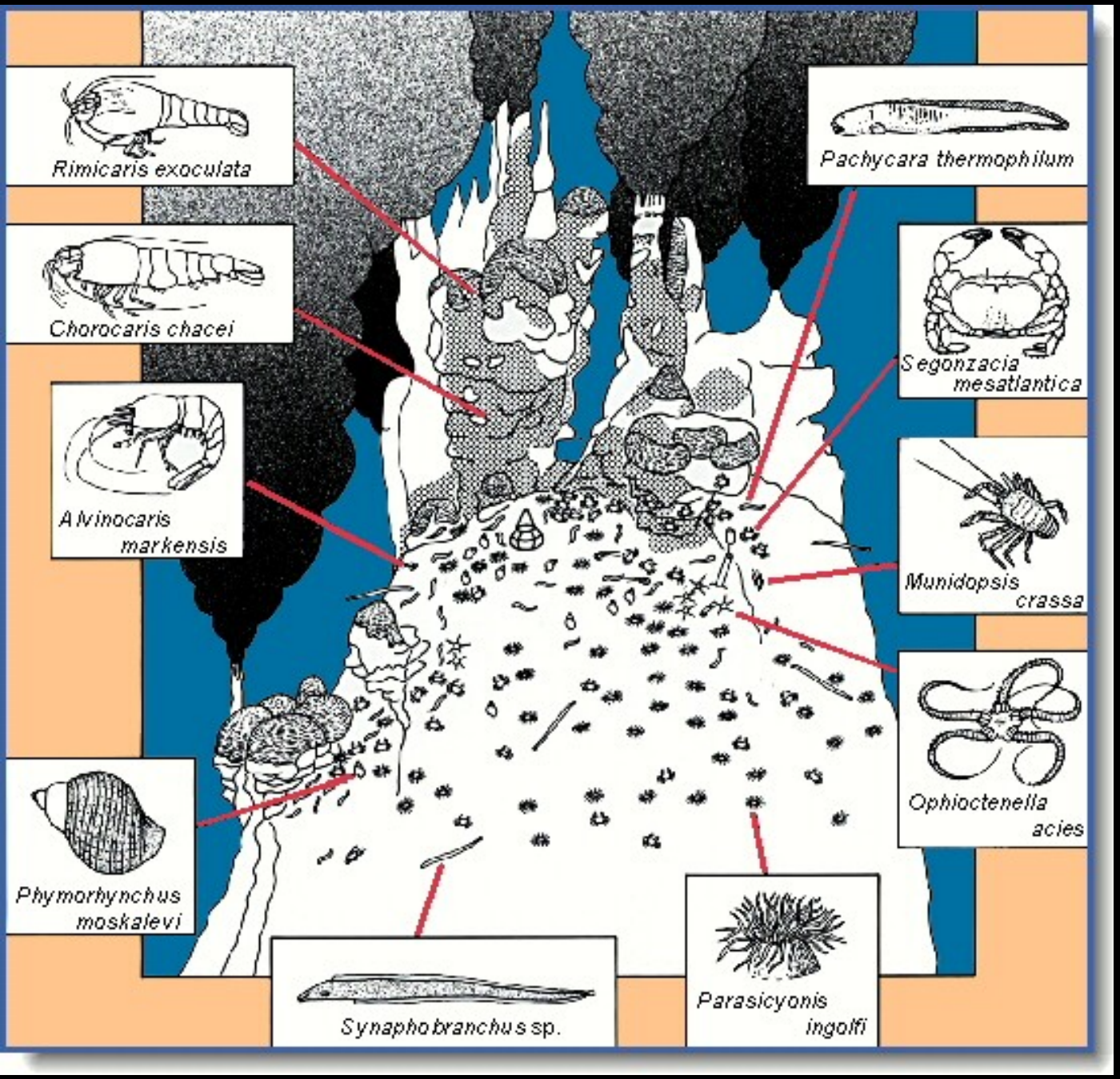
Jinks et al. 2003 (SCIENCE)



Vent community regulation

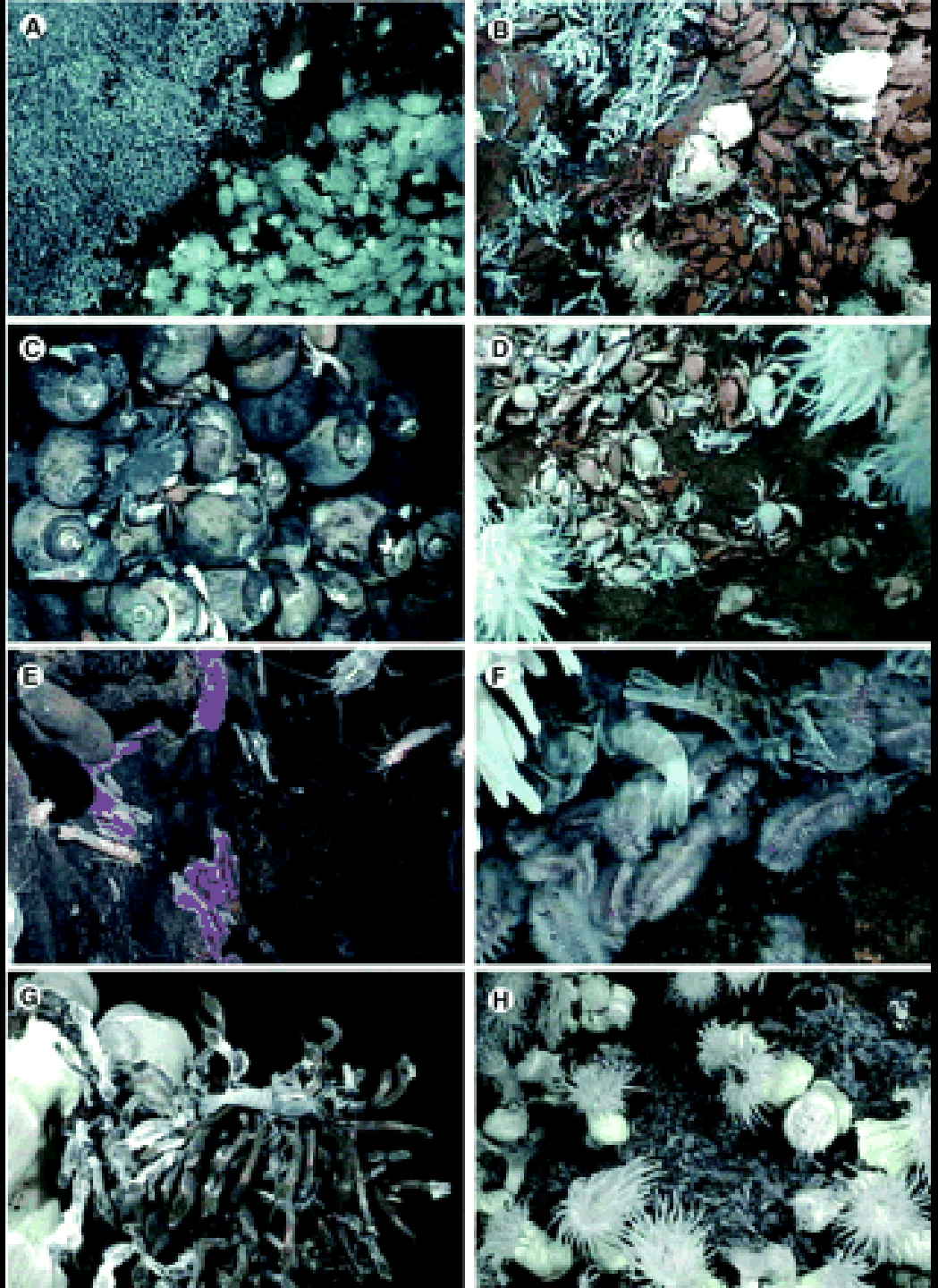
EPR Pacific

http://mollie.berkeley.edu/~volkman/



Vent community regulation

Snake-Pit Mid Atlantic Ridge



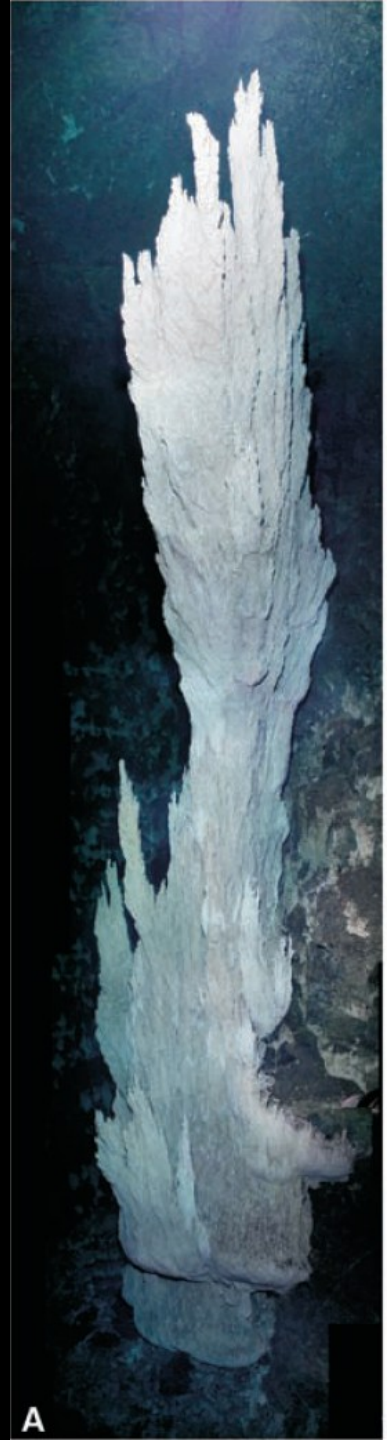
Vent community regulation

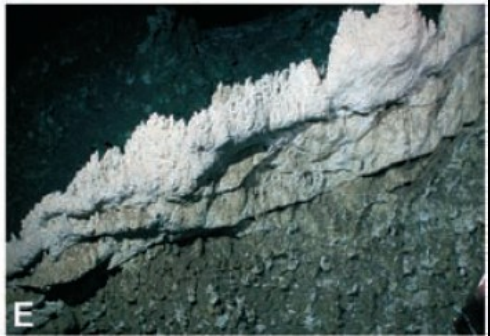
Indian Ocean

Vent community regulation

- Physical factors
  - Temperature
- Ecological factors
  - Competition
  - Larval supply
  - Predation
  - Ecological cascading – Keystone predators

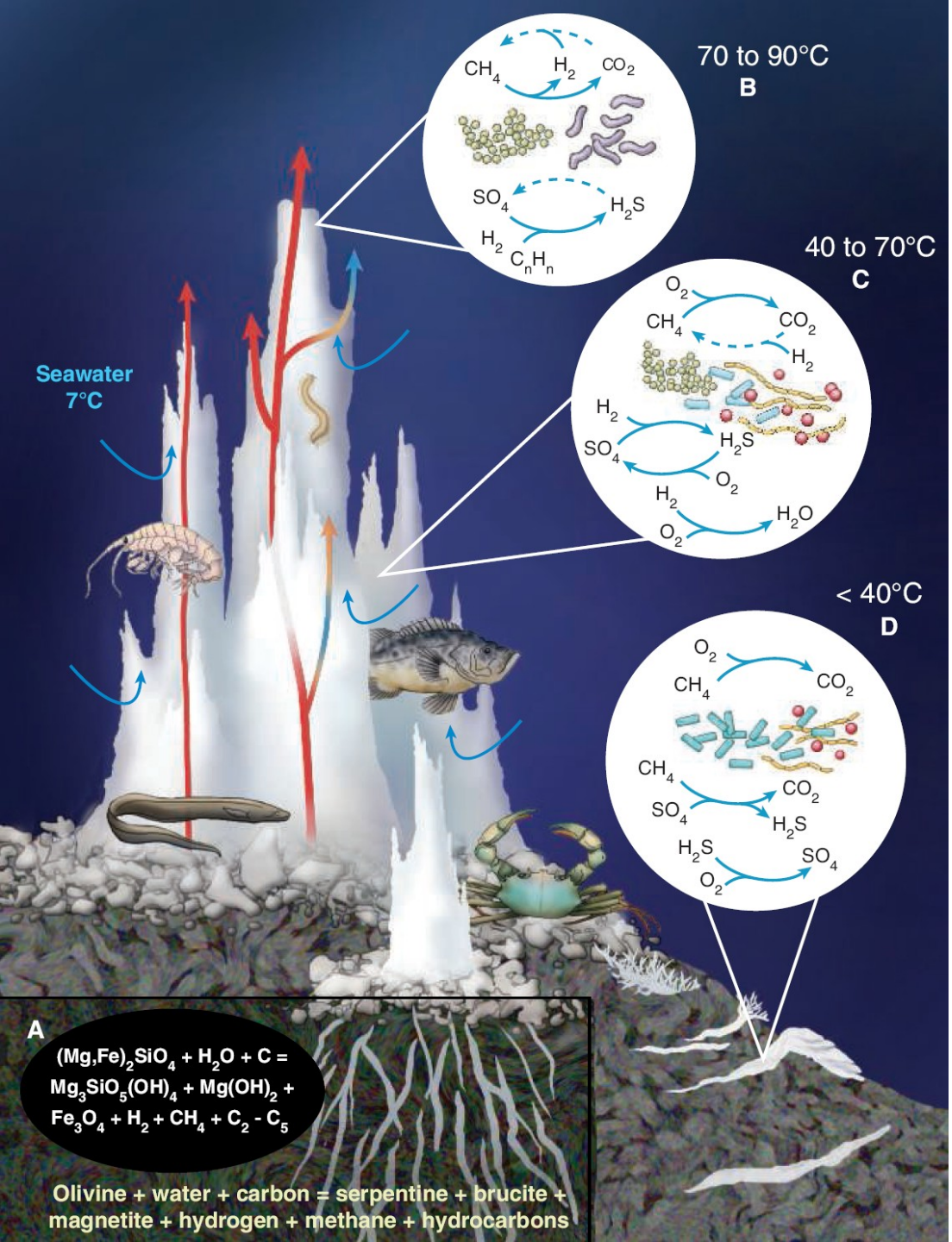
http://www.pmel.noaa.gov/vents/nemo/index.html

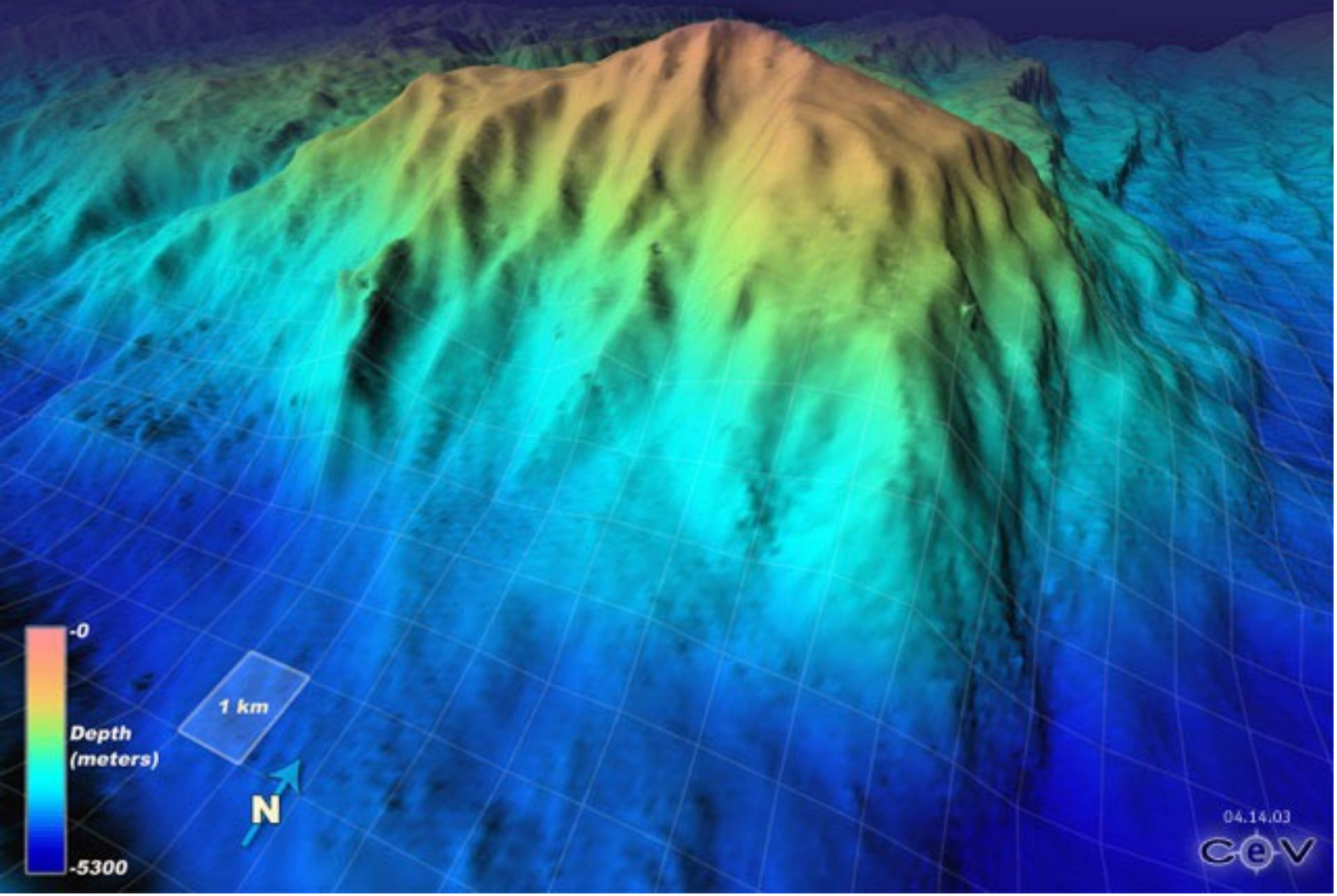




Lost City

Chemical Reactions

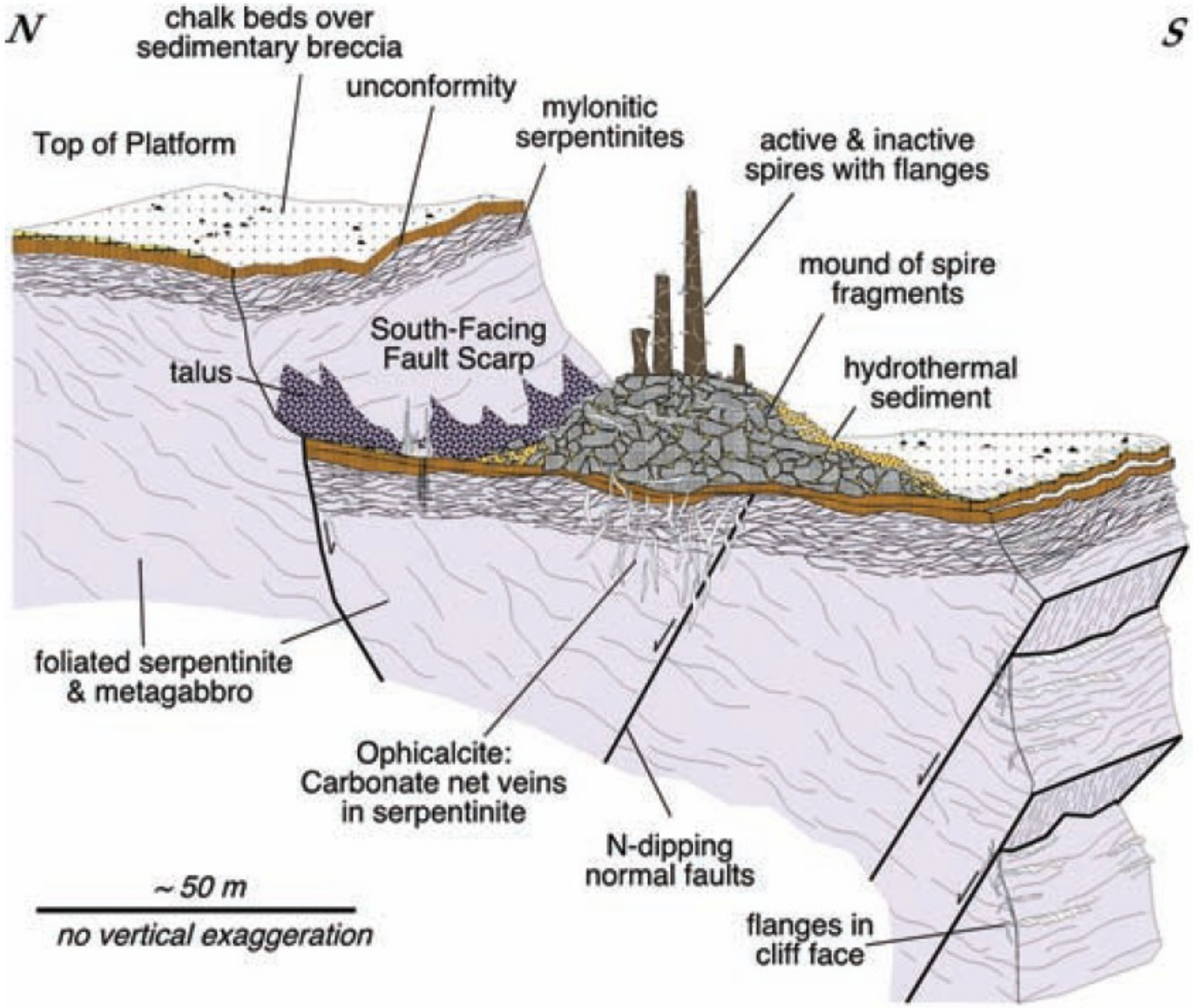


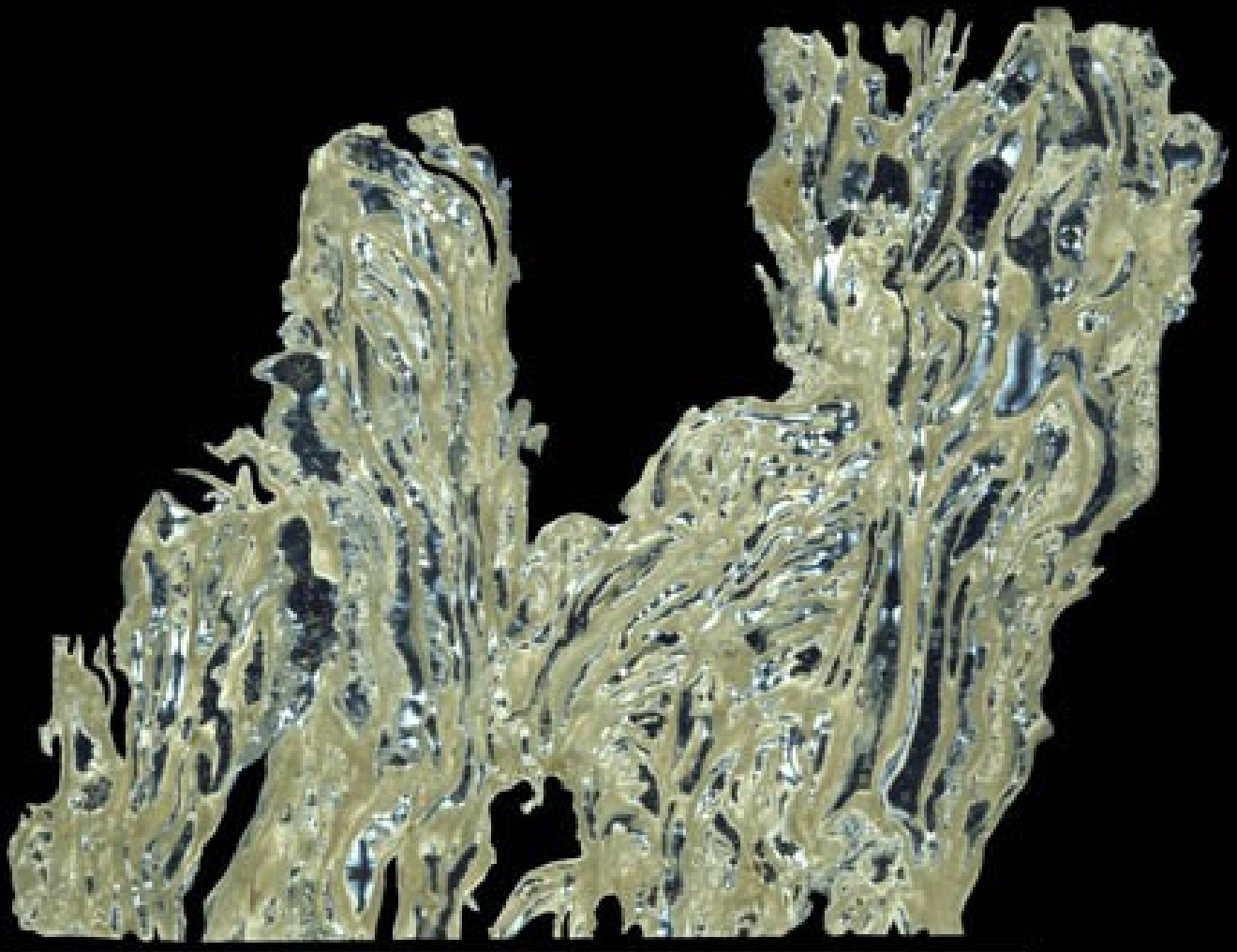


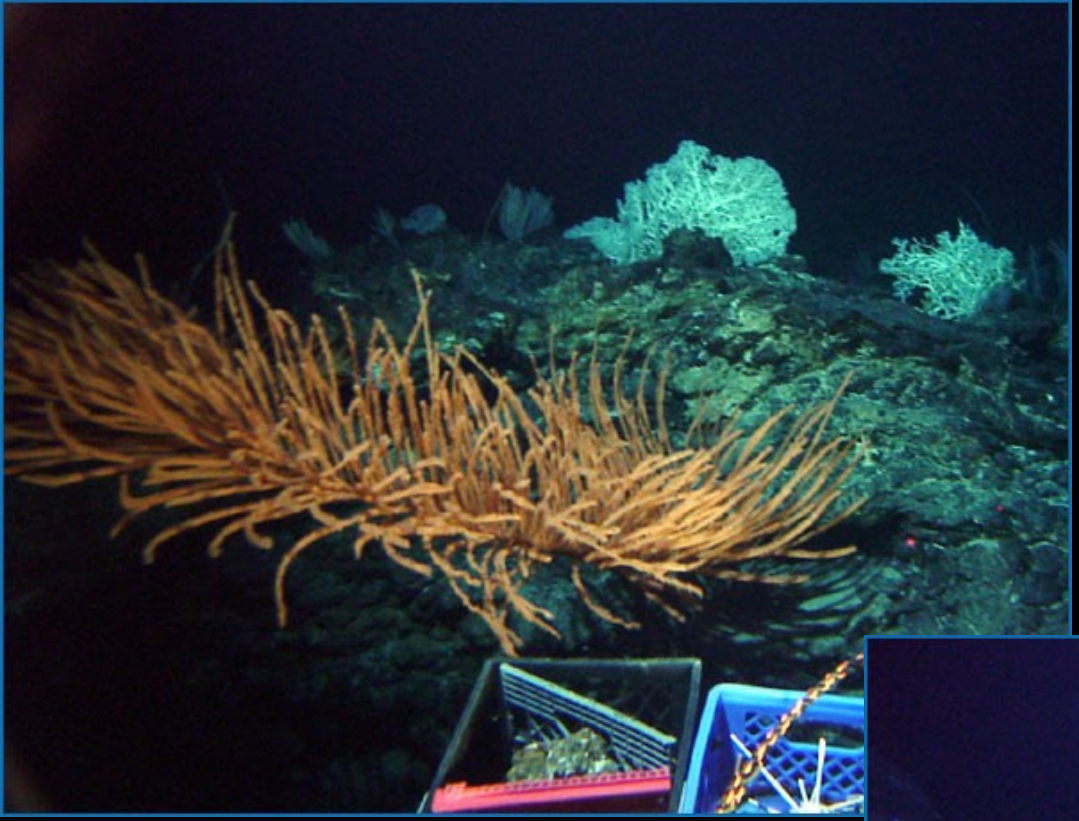
Olivine Density = 3.3 g/cm^3

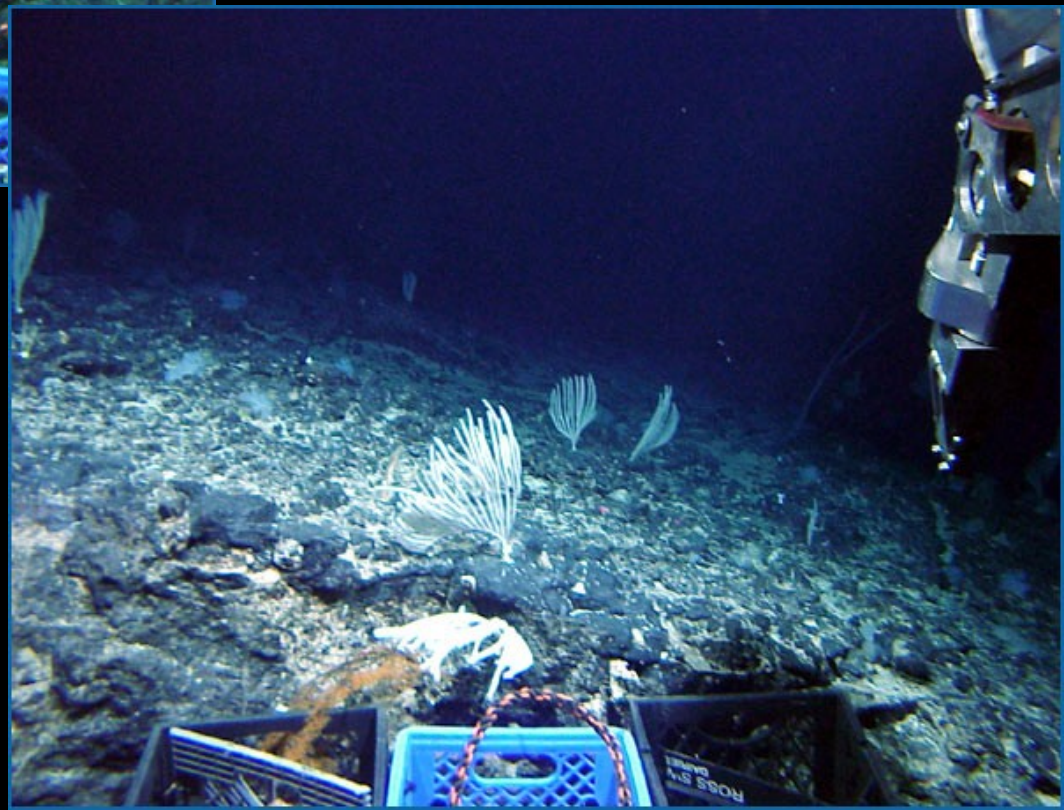
Serpentine Density = 3.3 g/cm^3

40% Increase Volume


N
S
chalk beds over
sedimentary breccia
unconformity
mylonitic
serpentinites
Top of Platform
active & inactive
spires with flanges
mound of spire
fragments
South-Facing
Fault Scarp
talus
hydrothermal
sediment
foliated serpentinite
& metagabbro
Ophicalcite:
Carbonate net veins
in serpentinite
N-dipping
normal faults
flanges in
cliff face
~ 50 m
no vertical exaggeration

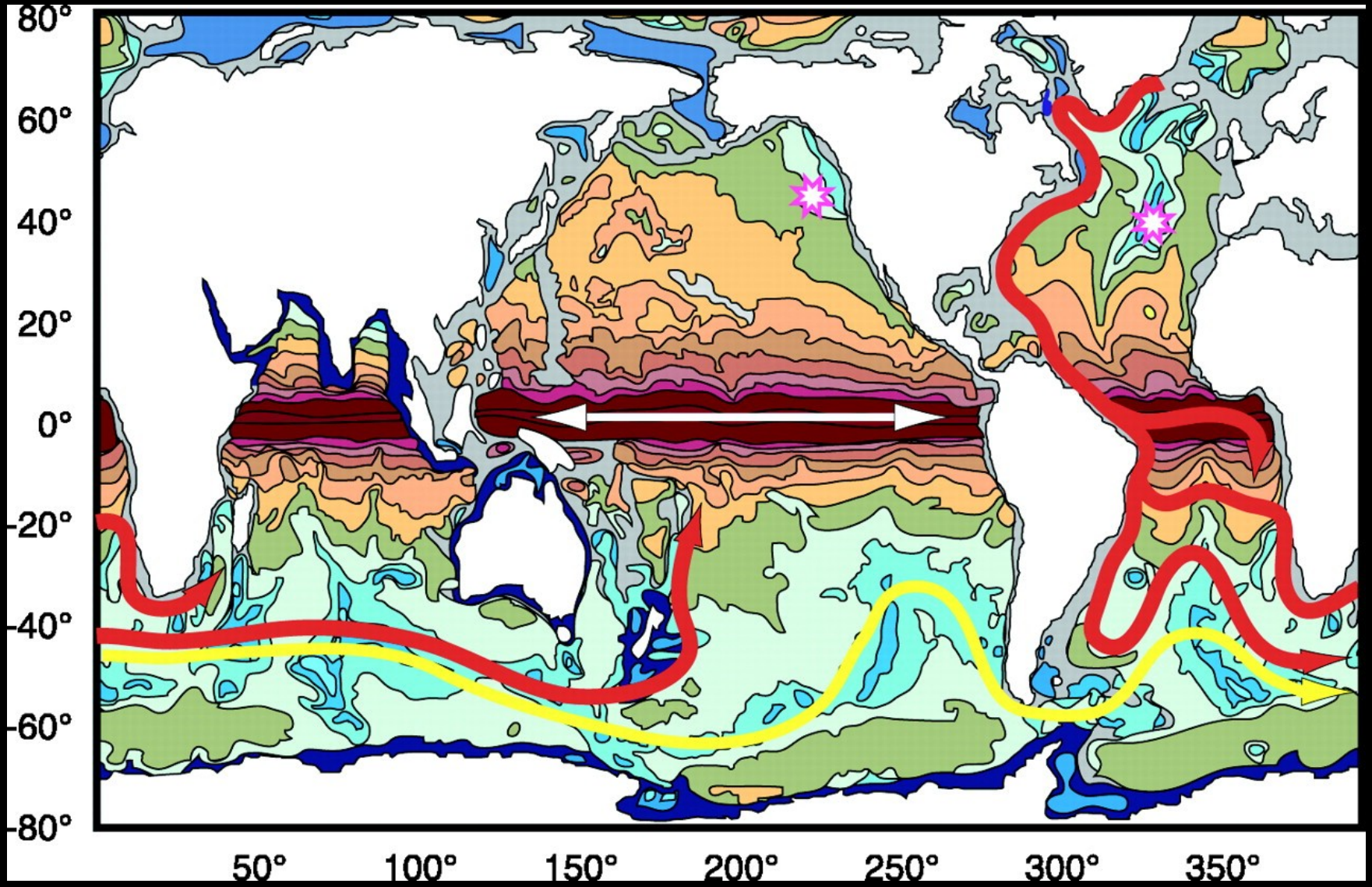

2.5 cm





Lost City

- **Serpentinization**
  - Olivine → Serpentine (hydration)
  - Exothermic reaction 260°C
  - Basic fluids pH 9-10 ($CaCo_3$ precipitate)
  - Fluids contain high CH_4 and H_2
  - 30.000 of *Age*


80°
60°
40°
20°
0°
-20°
-40°
-60°
-80°
50°
100°
150°
200°
250°
300°
350°