

The Sea Floor

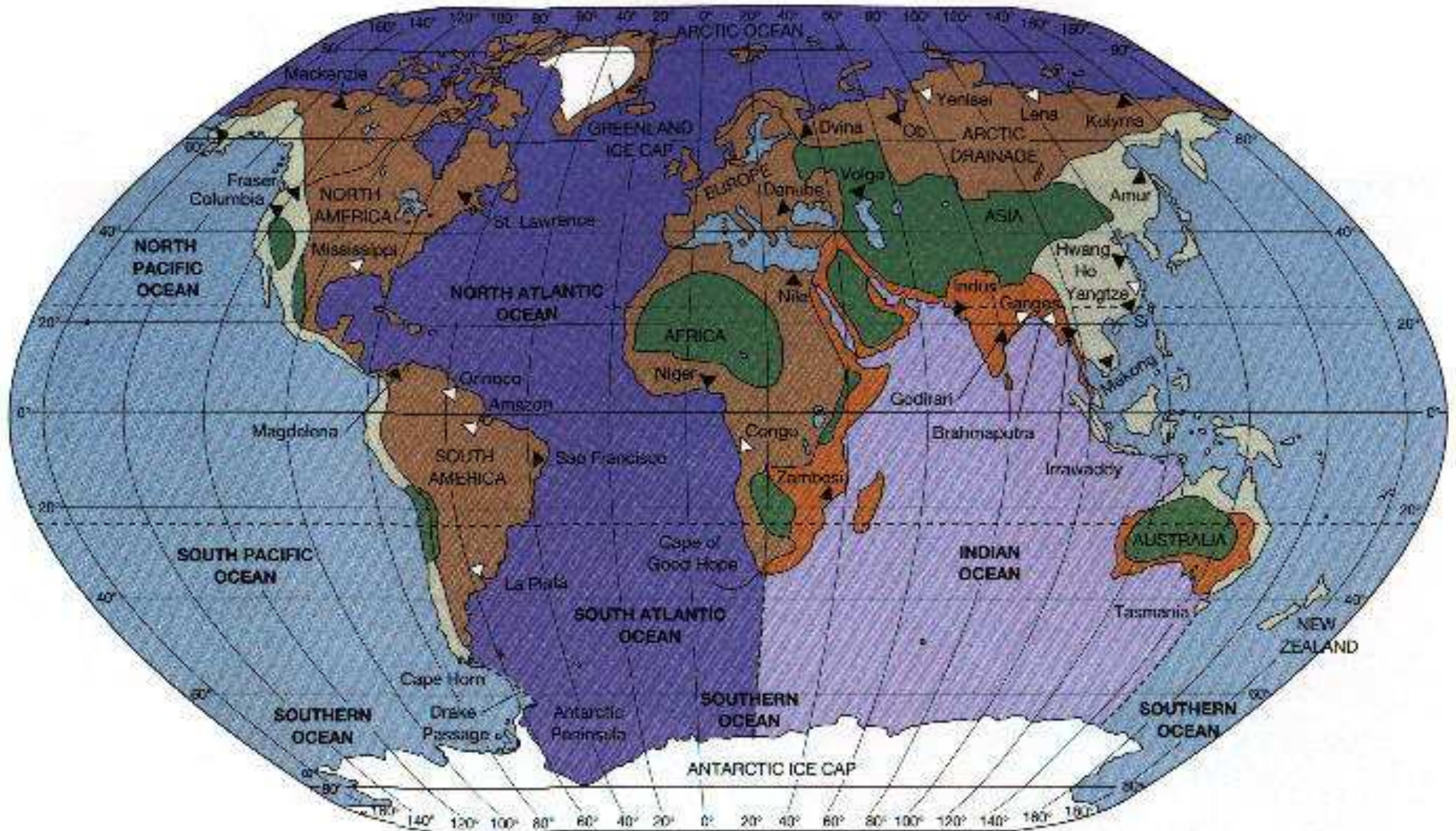
Chapter 3

The Water Planet

- Over 70% of Earth's surface is covered by water (70.8 to be precise)
 1. 97% in SW of oceans and seas
 2. 2% FW Lakes and rivers
 3. 1% snow and ice as glaciers
 4. 0.00057% - atmospheric water
- Prior to 1950, little was known about the deep ocean floor

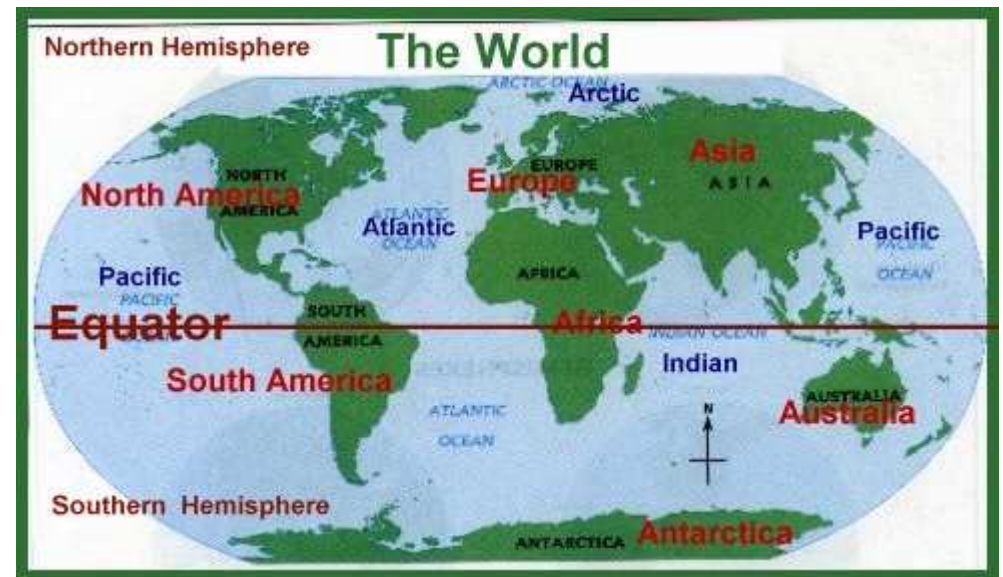


4 primary oceans (Pacific, Atlantic, Indian, Arctic)



Water:Land

- Land not distributed evenly over globe –
- In Northern Hemisphere ratio of water to land = 1.5 /1
- In Southern Hemisphere ratio 4/1.



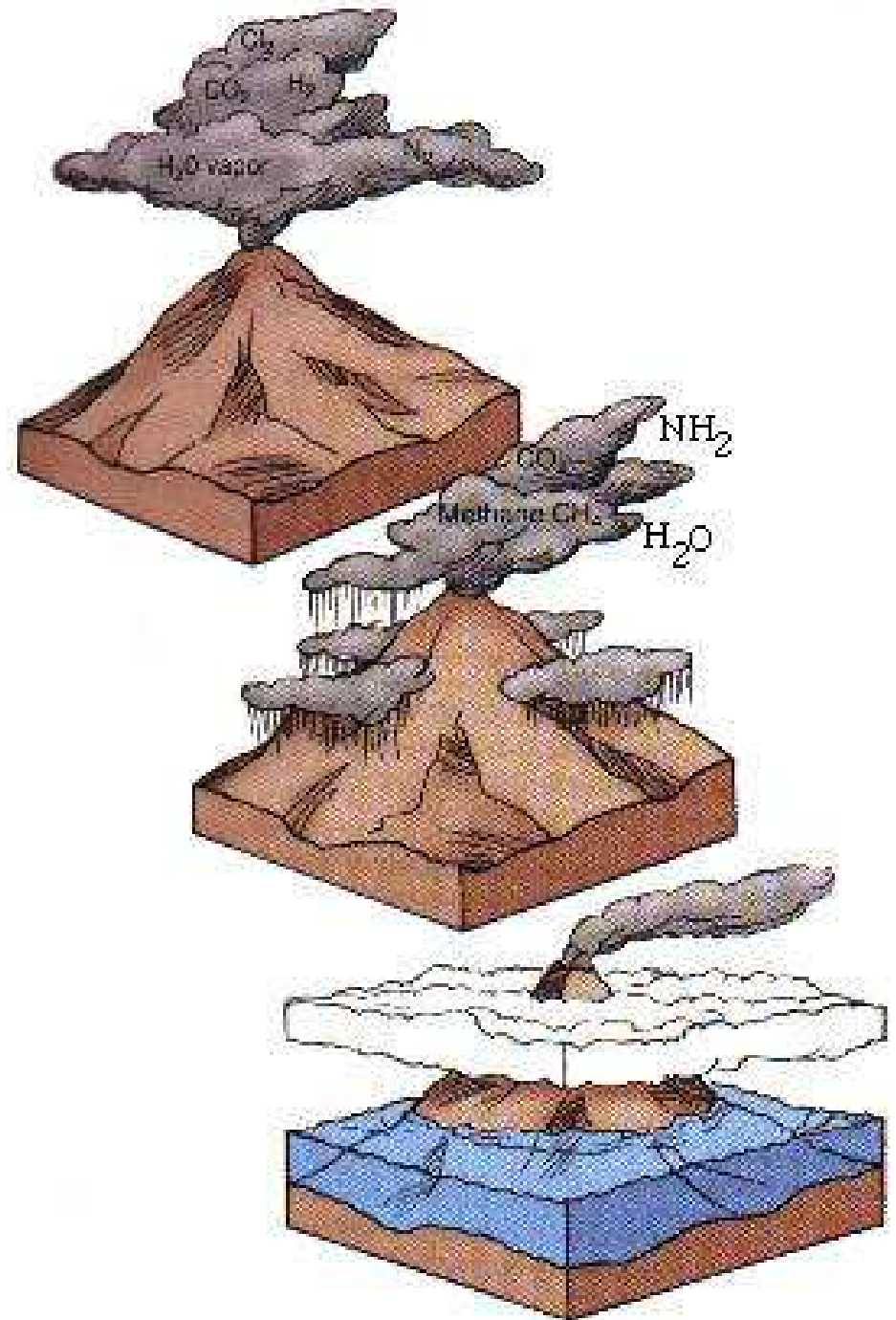
Origin of Oceans

- Oceans originated primarily from *volcanic degassing* of water vapor from Earth's interior
 - oceans formed because around 4.5 billion years ago, it rained constantly for couple million yrs
- Small additional amount of water may have come from comets (extraterrestrial sources of ice) bombarding the Earth

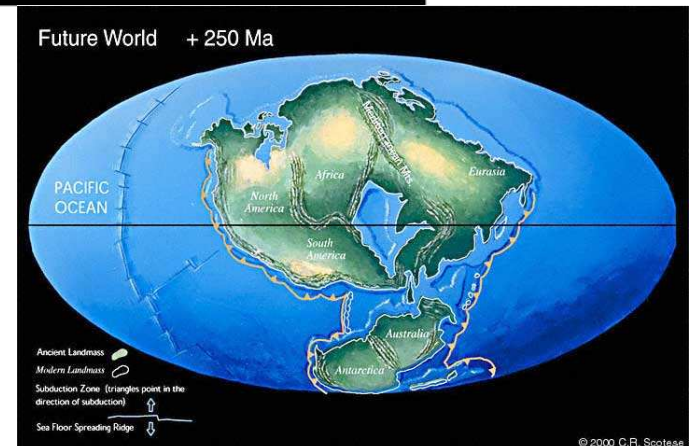
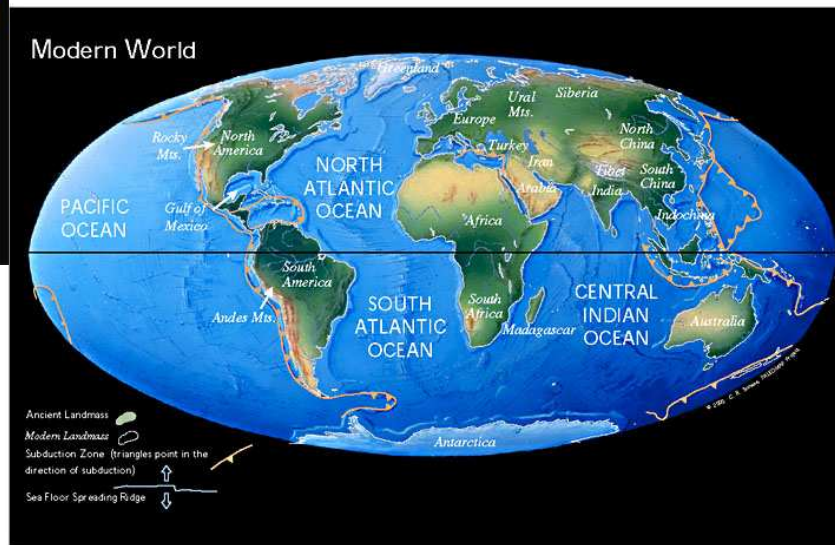
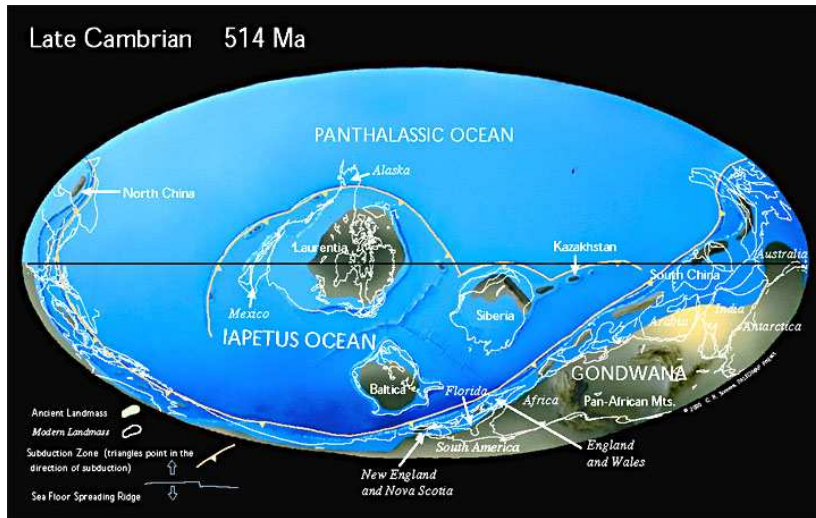


Origins of the Ocean

- product of volcanic degassing



Changes in Size of Ocean Basin

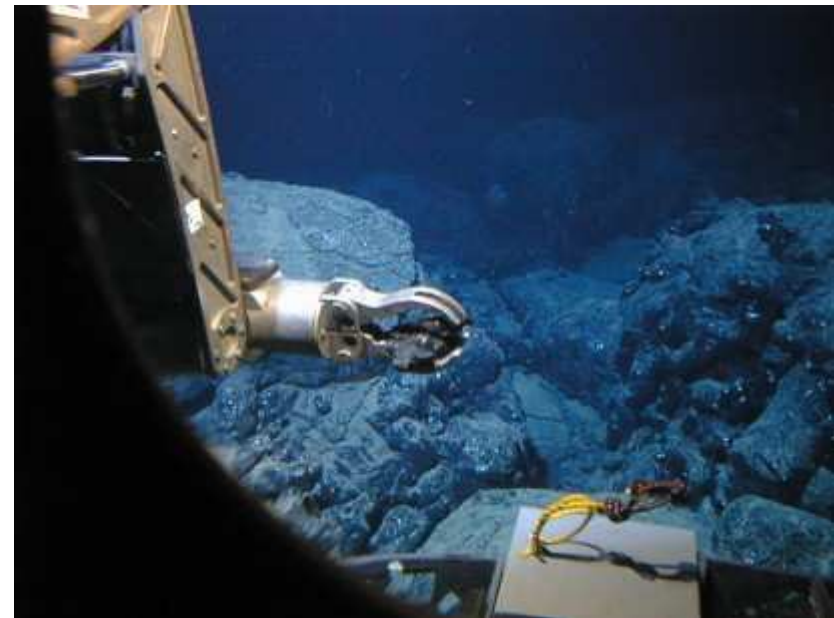


Studying the Sea Floor

- Sea floor is generally *difficult* to study
- Sea floor rocks and sediments sampled using *rock dredges*, *seafloor drilling*, or *submersibles*

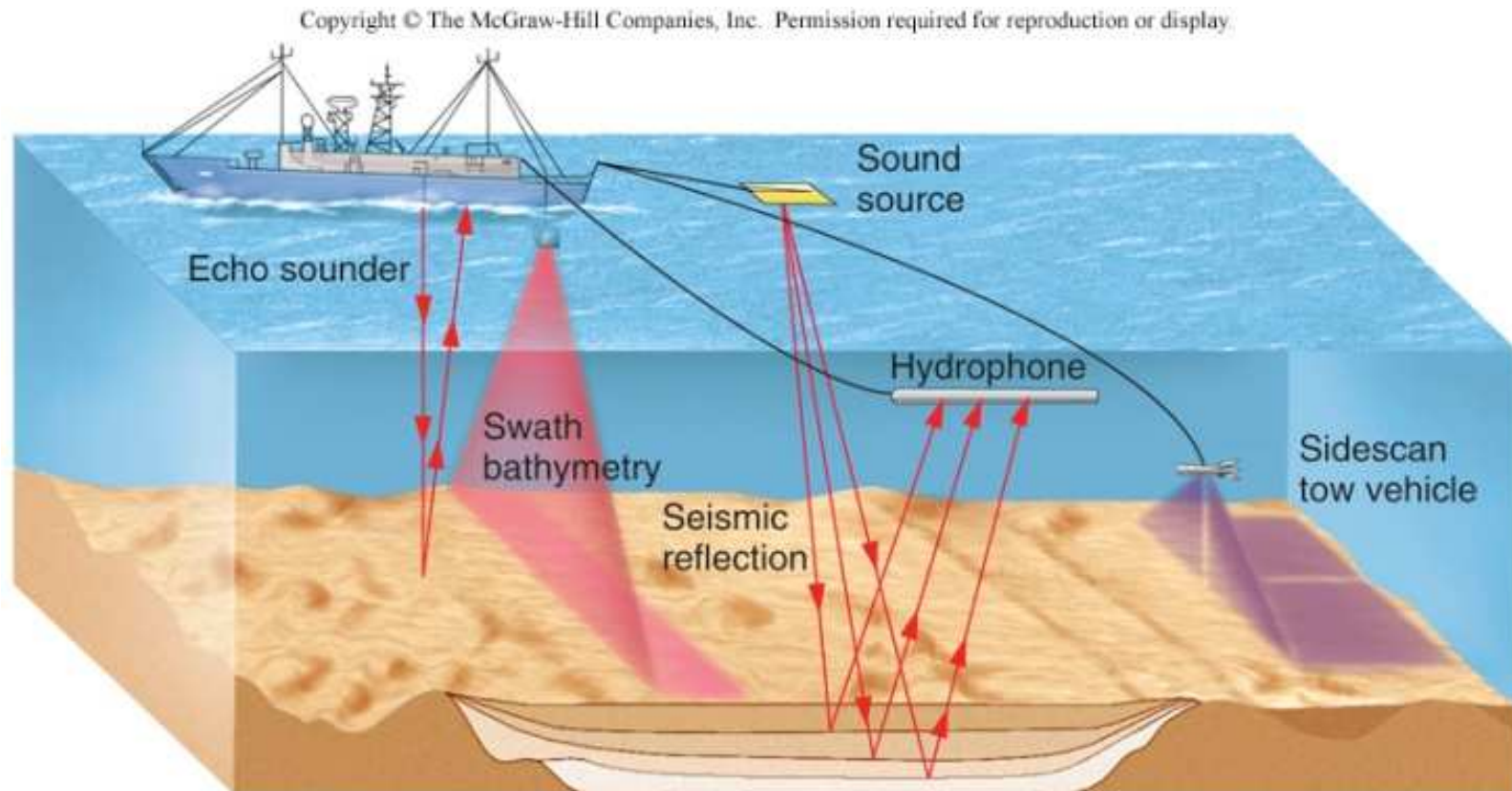


Methods of Study – ROVs



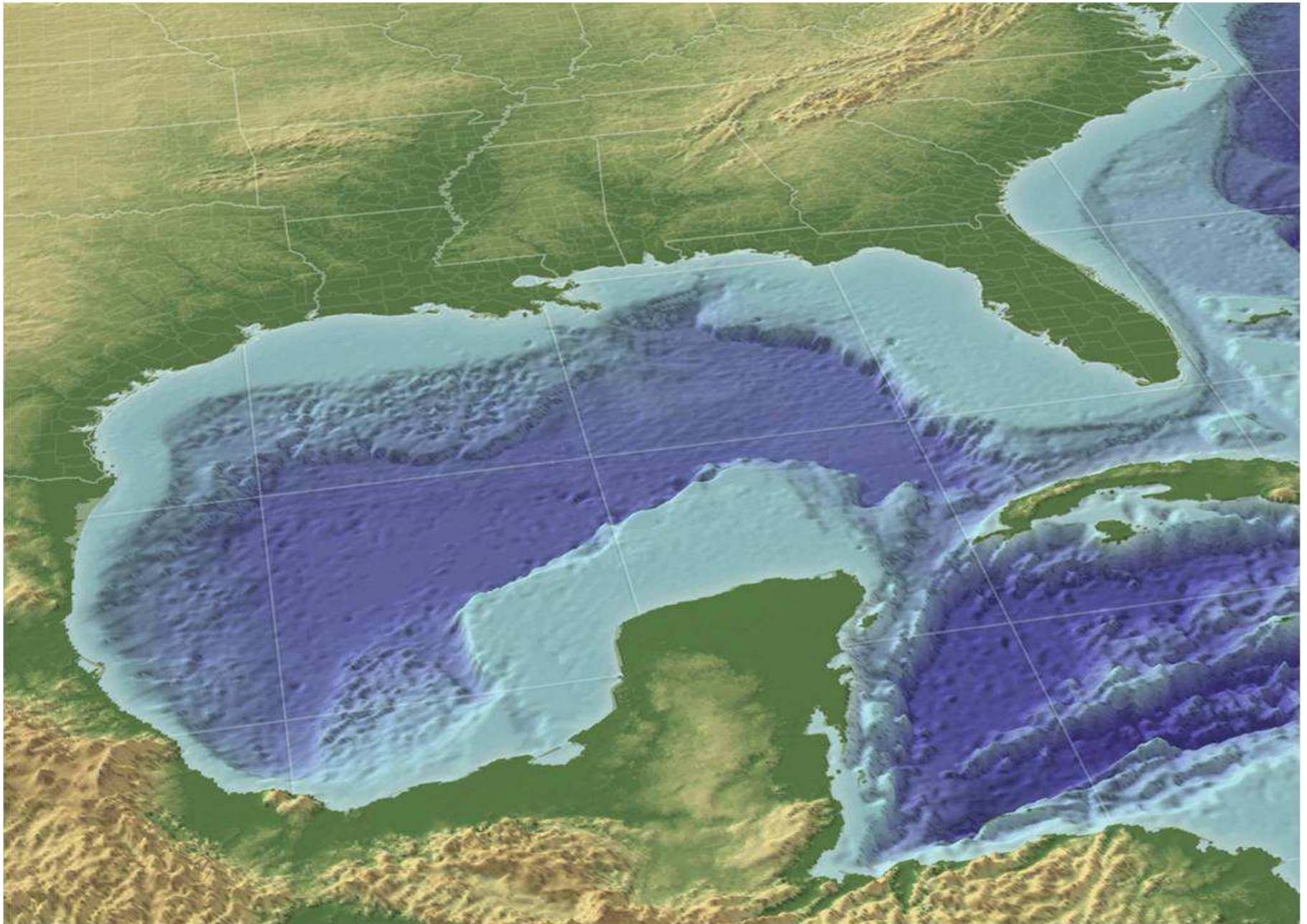
Studying the Sea Floor

- Indirect observations of the sea floor with *sonar* (sound navigation and ranging) and *seismic reflection profiling*



Modified from U.S. Geological Survey Fact Sheet 039-02

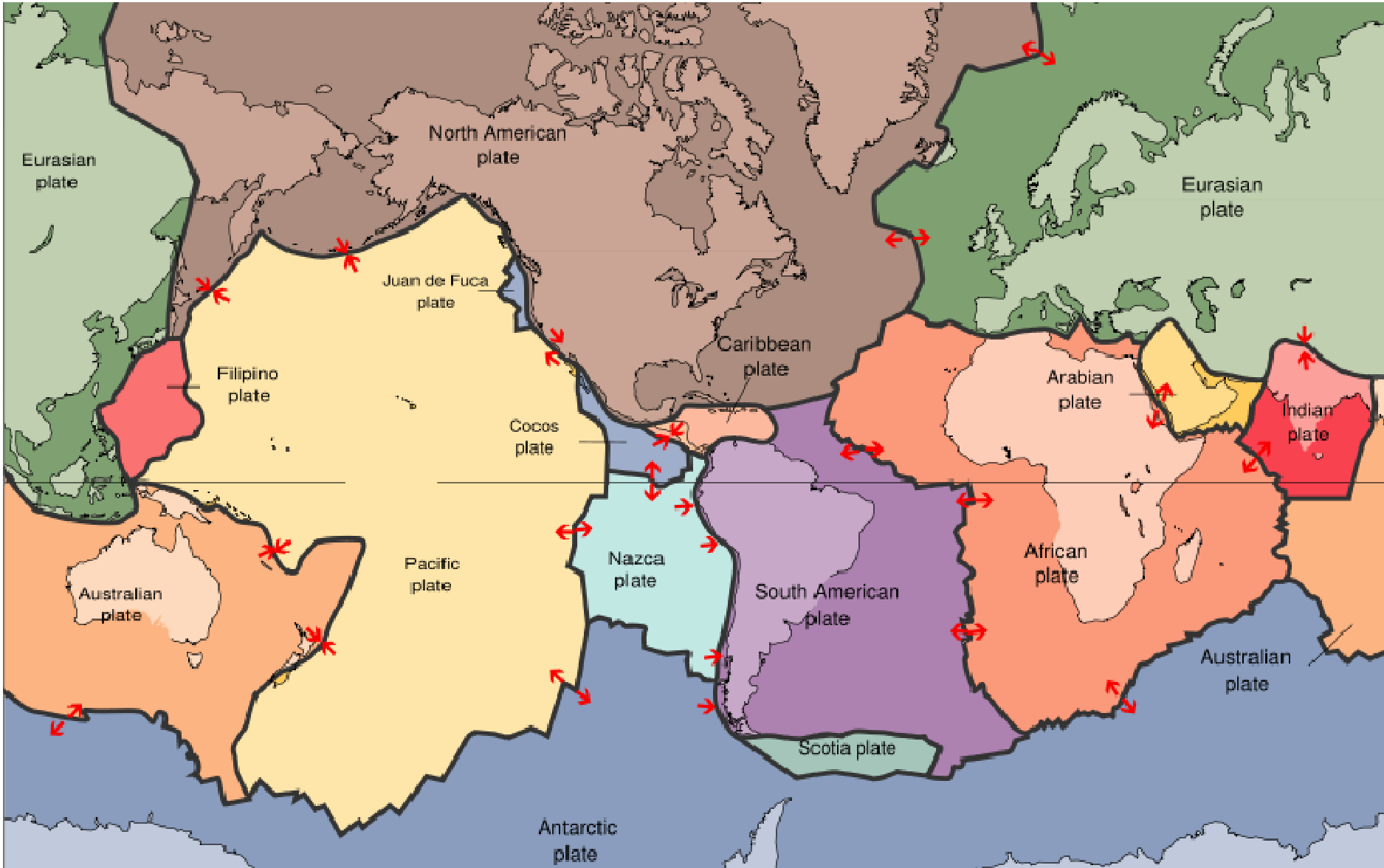
Studying the Sea Floor



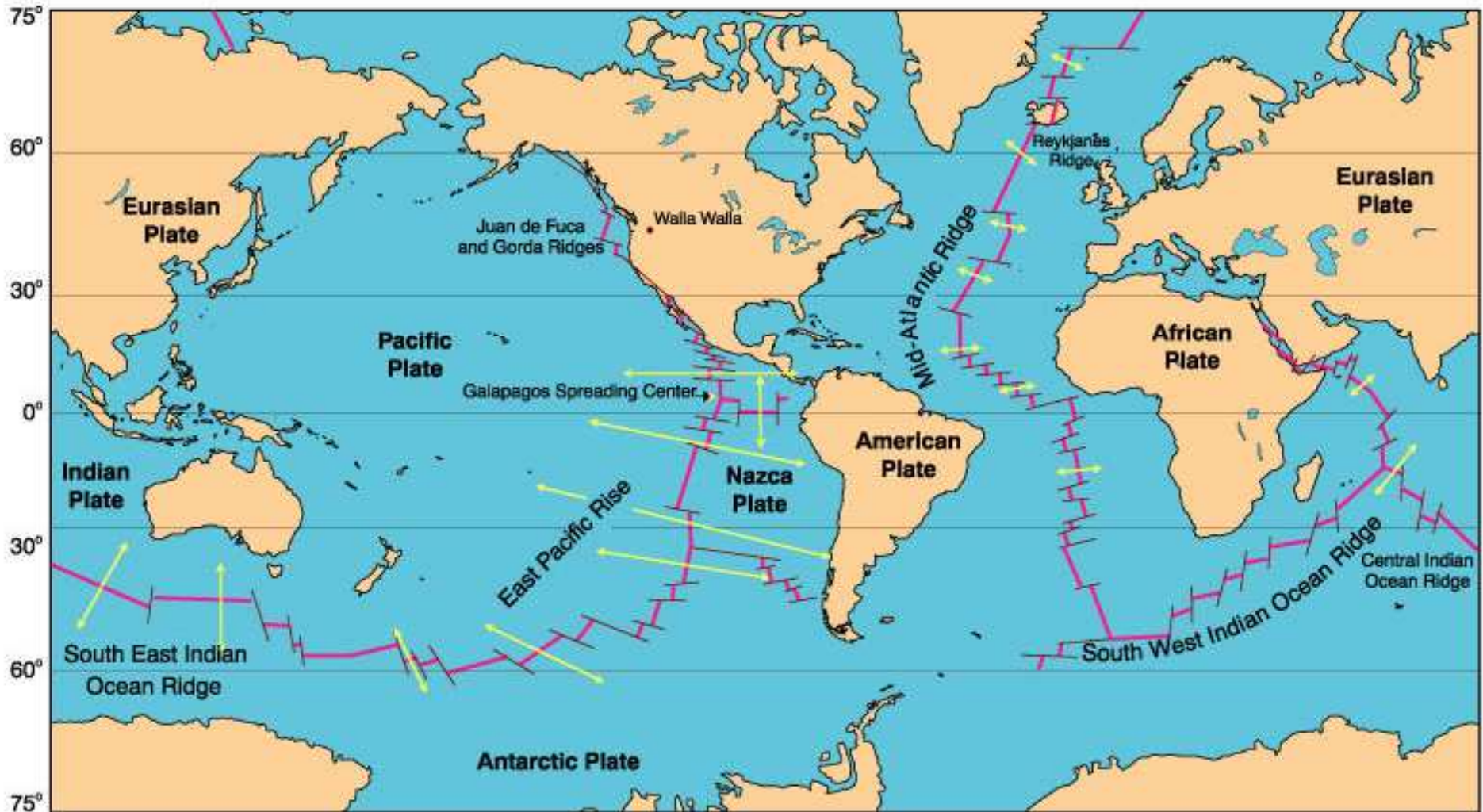
Active vs. Passive Continental Margin

- An active continental margin is found on the leading edge of the continent where it is crashing into an oceanic plate.
- Active margins are commonly the sites of tectonic activity: earthquakes, volcanoes, mountain building, and the formation of new igneous rock.
- Passive continental margins are found along the remaining coastlines. Because there is no collision or subduction taking place, tectonic activity is minimal
- The North American plate provide excellent example to illustrate this difference. The west coast is the active margin, and the Eastern Seaboard is a passive margin.

Passive Vs. Active Continental Margins



Active vs. Passive Continental Margin



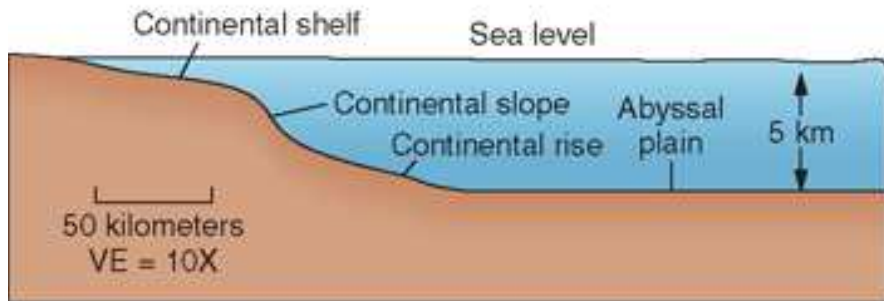
Features of the Sea Floor

- *Different margins = Different features*
- Passive continental margins have a *continental shelf*, *continental slope*, and *continental rise* descending to the *abyssal plain*
- *Active continental margins* have continental shelves and slopes, but the slope extends down into a deep *oceanic trench*

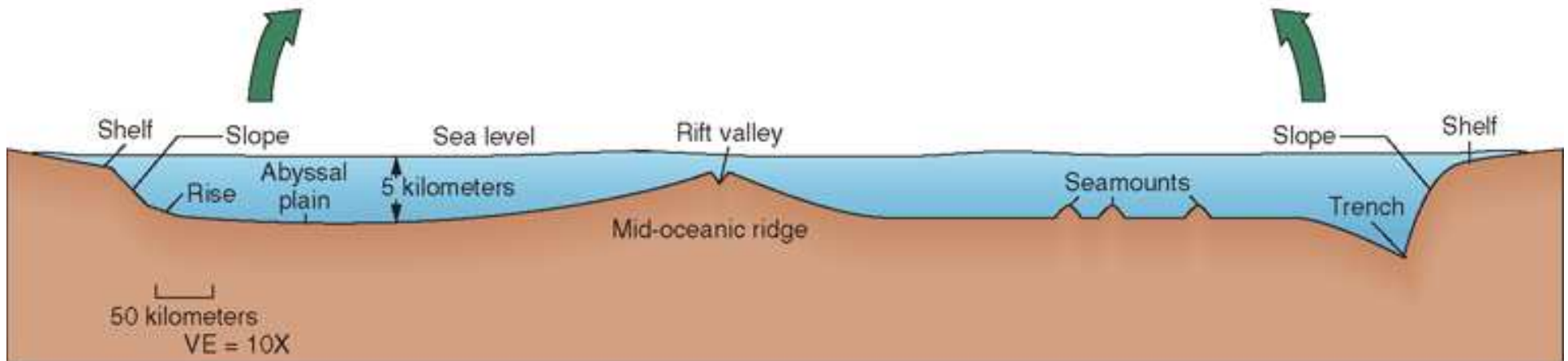
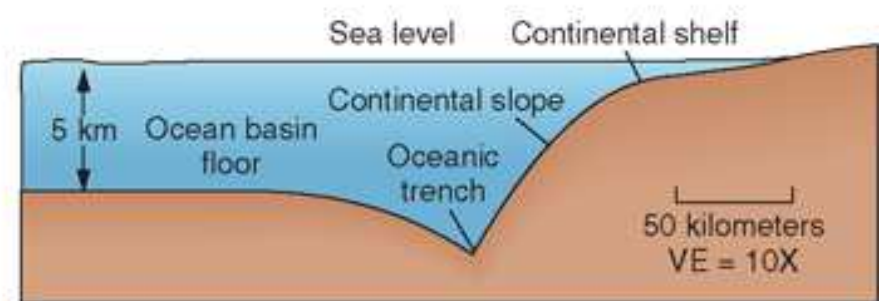
Features of the Sea Floor

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PASSIVE CONTINENTAL MARGIN



ACTIVE CONTINENTAL MARGIN



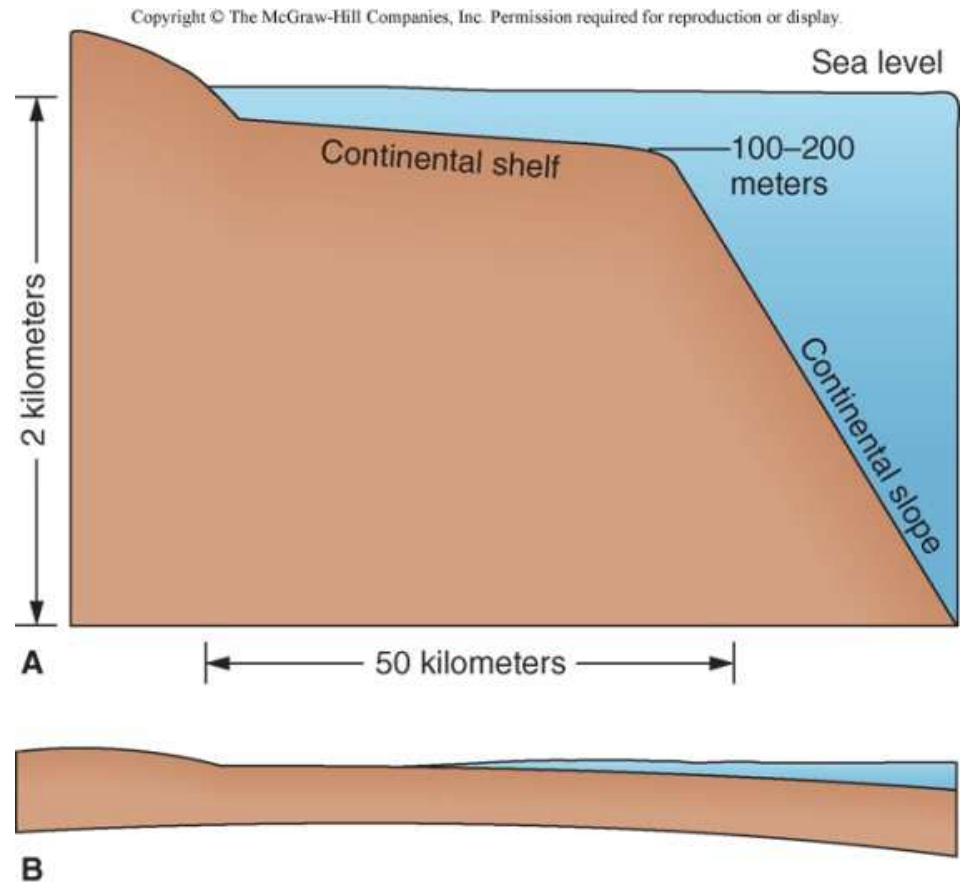
Continental Shelves and Slopes

Continental shelves - gently (0.1°)

seaward-sloping shallow submarine platforms at the edges of continents

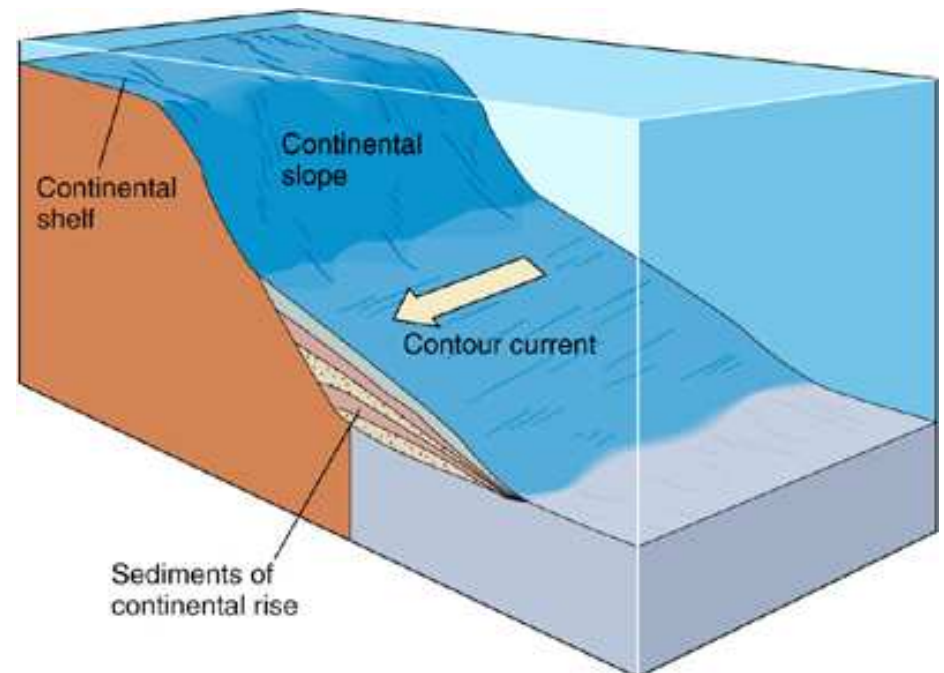
- Range in width from a few km to >500 km
- Typically covered with young sediments

Continental slopes - relatively steep slopes (typically $4-5^\circ$, but locally much steeper) that extend down from the edge of the continental shelf to the abyssal plain

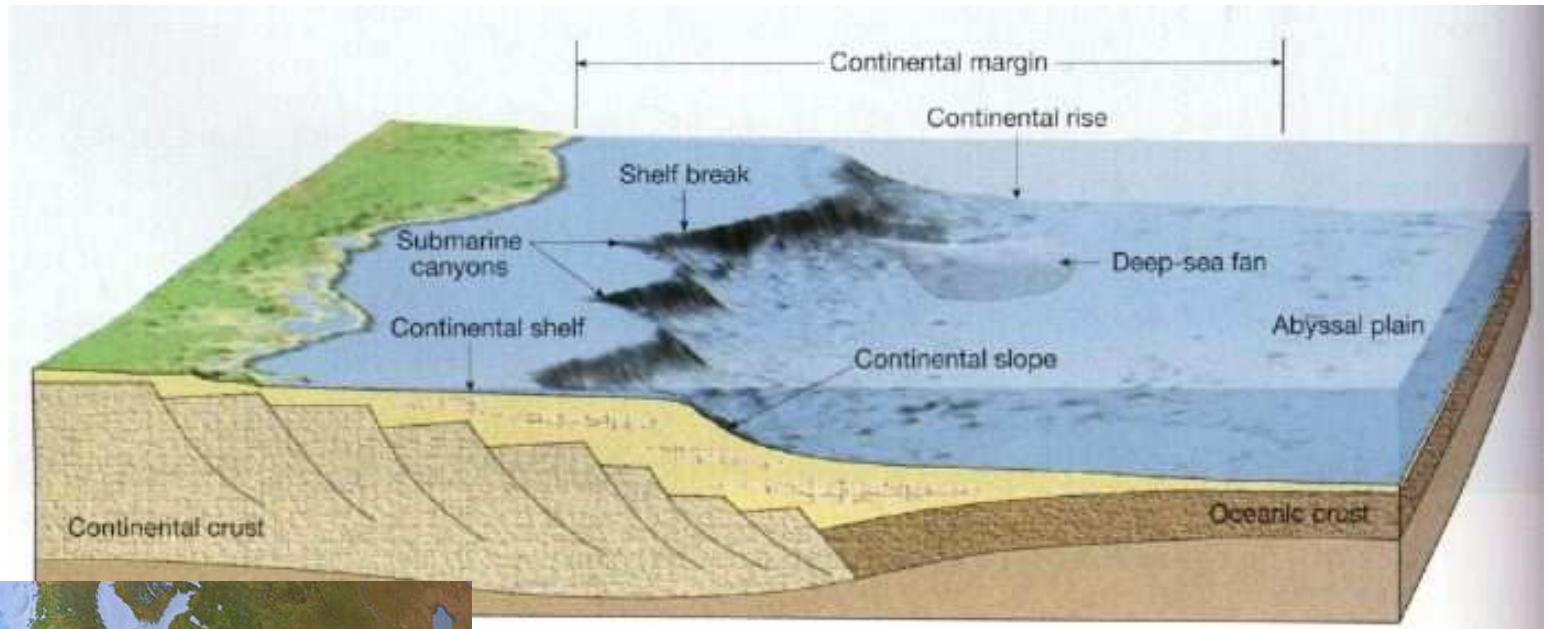


Continental Rises and Abyssal Plains

- *Continental rises* - gently seaward-sloping (0.5°) wedges of sediments extending from base of continental slope to deep sea floor
 - Sediment deposited by *turbidity* and *contour currents*
 - End at *abyssal plain* at depth of about 5 km
- *Abyssal plains* - extremely flat regions beyond the base of the continental rise
 - Flattest features on Earth, with slopes $<0.01^\circ$

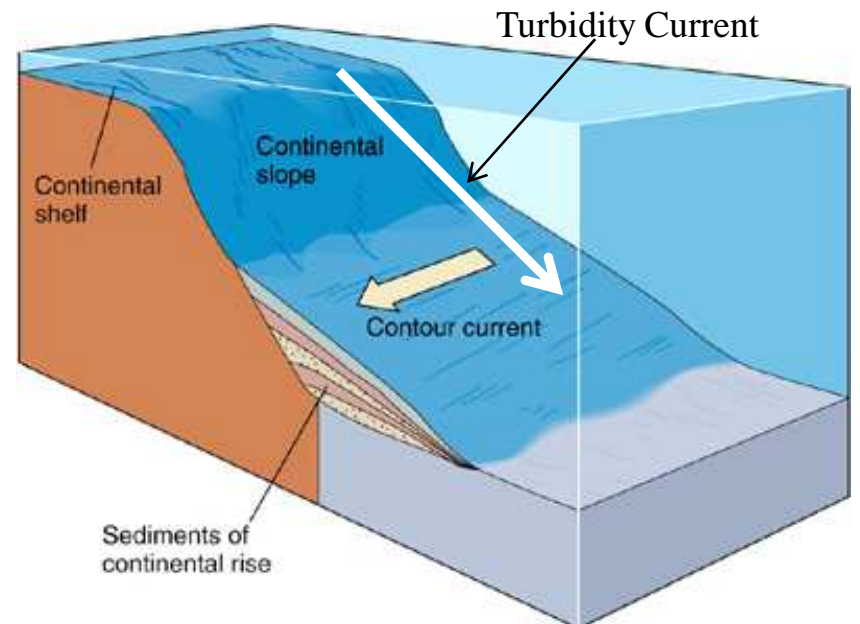


Major Features of Oceans across non tectonic continental margins (passive margins)



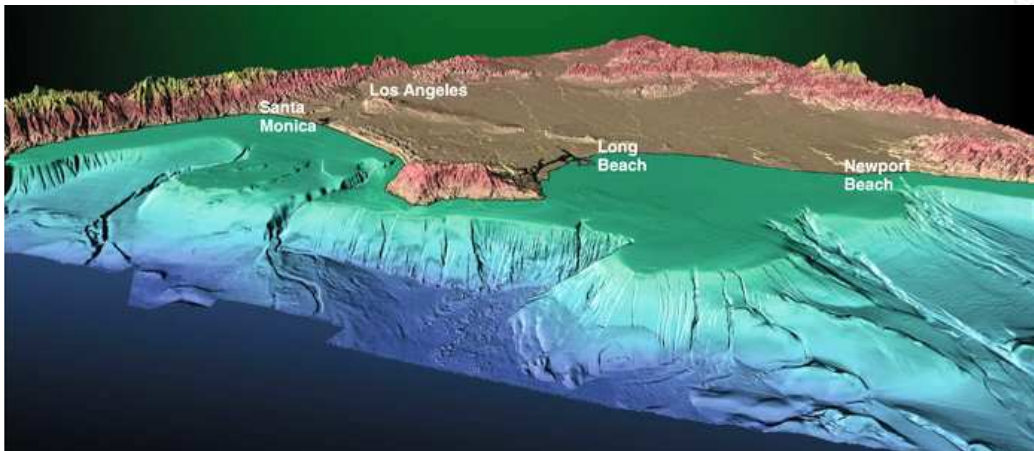
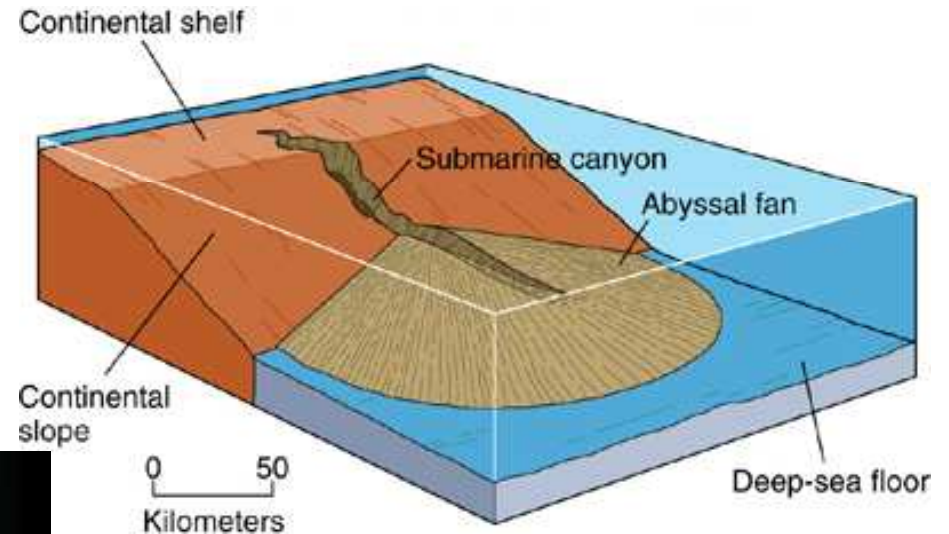
Currents at Seafloor

- Two types
- Turbidity Currents and Contour Currents
- Turbidity current flowing down the continental slope
- Contour current flowing along the continental slope



Features on Continental Shelves and Slopes

- *Submarine canyons* - V-shaped valleys that run across continental shelves and down continental slopes
 - Deliver continental sediments to *abyssal fans* on deep sea floor, sometimes by *turbidity currents*

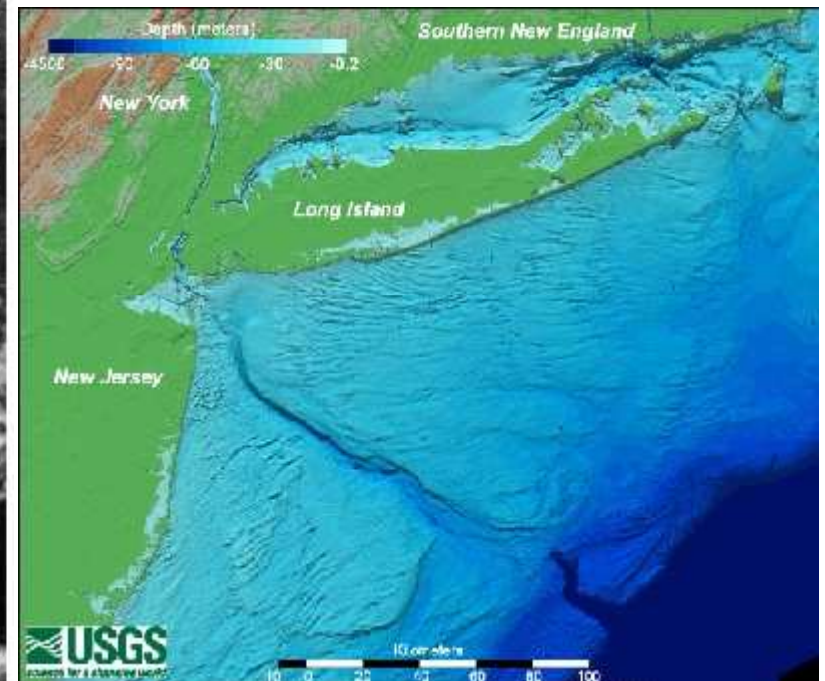


Evidence of Turbidity Current

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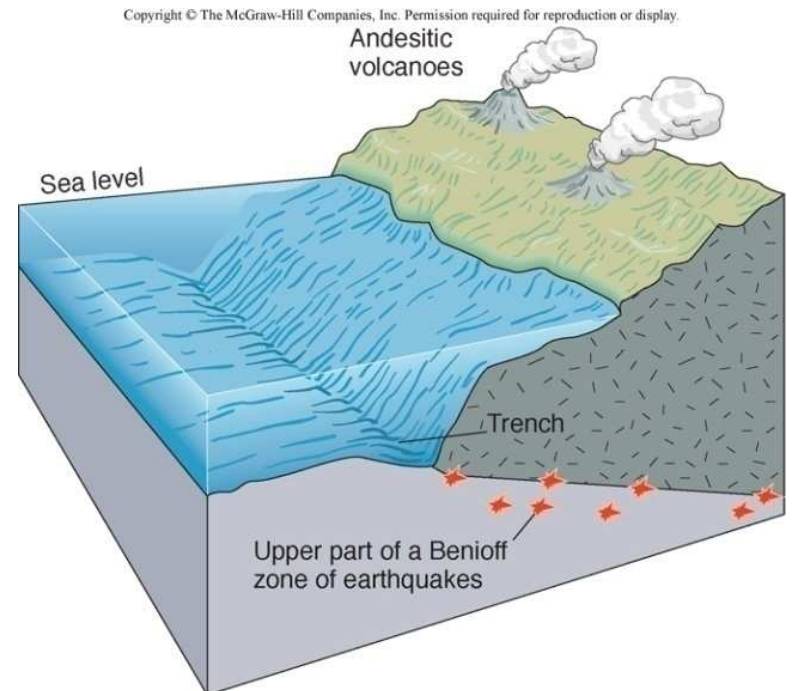
Scripps Institution of Oceanography, University of California, San Diego



Hudson canyon

Oceanic Trenches

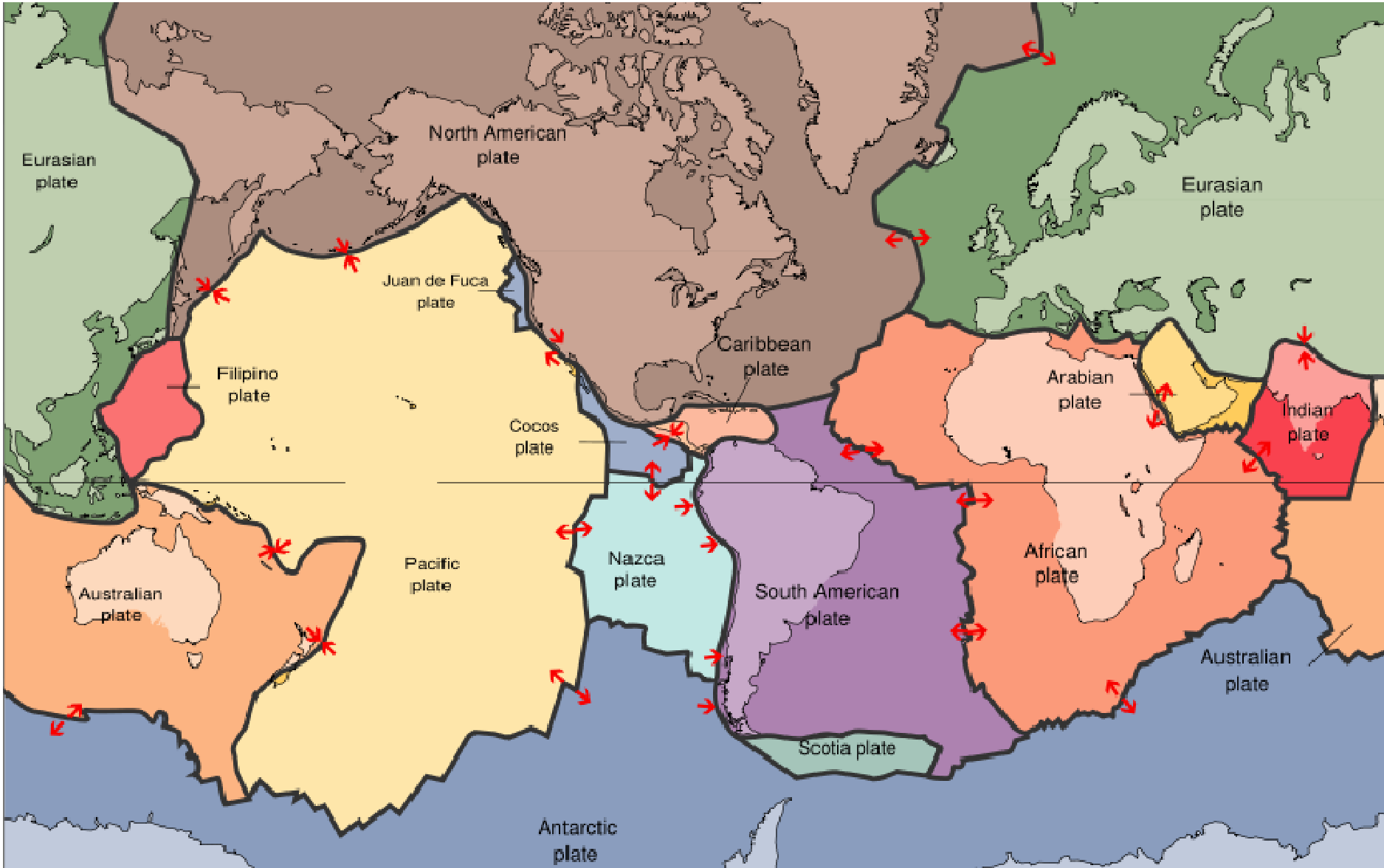
- An *oceanic trench* is a narrow, deep trough parallel to the edge of a continent margin
 - Deepest parts of the oceans
 - *Benioff zone* (after Hugo Benioff) for earthquake begin at trenches and dip landward under continents
 - Volcanoes found above upper part of Benioff zone arranged in long belts parallel to trenches



Oceanic Trenches

1. The **Mariana Trench** is the deepest part of the world's oceans, and the deepest location on the surface of the Earth's crust.
2. It has a maximum depth of about 11 km (6.8 mi), and is located in the western North Pacific Ocean, to the east and south of the Mariana Islands, near Guam.
3. The trench forms the boundary between two tectonic plates, where the Pacific Plate is subducted beneath the Philippine Plate.
4. The bottom of the trench is farther below sea level than Mount Everest is above it (8,850m/29,035ft).
5. The trench was first surveyed in 1951 by the Royal Navy vessel *Challenger*, which gave its name to the deepest part of the trench, the **Challenger Deep**

Passive Vs. Active Continental Margins



Mariana Trench

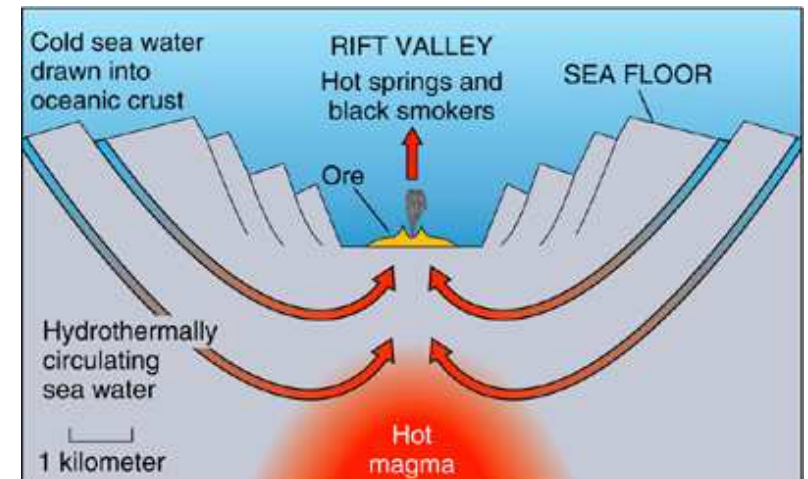
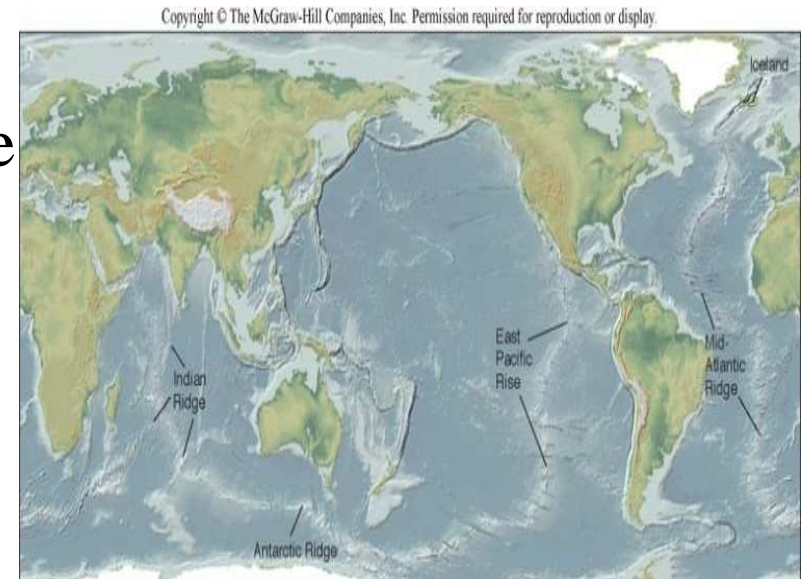


The United States Navy submersible manned vessel reached the bottom at 1:06 p.m. on January 23, 1960, with U.S. Navy Lieutenant Don Walsh and Jacques Piccard on board.

Mid-Oceanic Ridges

Mid-oceanic ridge - giant undersea mountain range extending around the world like the seams on a baseball

- Made mostly of young basalt flows
- More than 80,000 km long, 1,500-2,500 km wide, and rises 2-3 km above ocean floor
- A *rift valley*, 1-2 km deep, runs down the crest of the ridge
- Shallow focus earthquakes common
- Extremely high heat flow

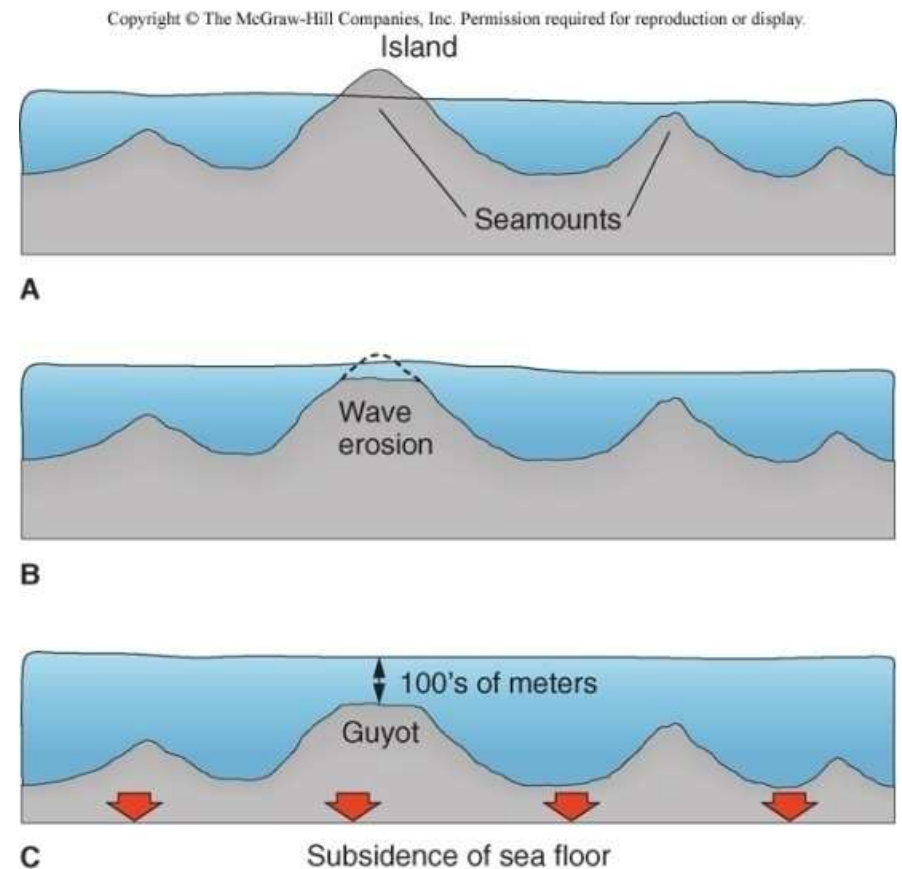


Seamounts and Guyots

Conical undersea mountains that rise ≥ 1000 m above the seafloor are called *seamounts*

- They are scattered along mid-oceanic ridges as a result of basaltic volcanic eruption
- Chains of seamounts form *aseismic ridges*

Guyots are flat-topped seamounts, apparently cut by wave action.



Coral Reefs

A **reef** is a rock, sandbar, or other feature lying beneath the surface of the water yet shallow enough to be a hazard to ships.

Many reefs result from abiotic processes—deposition of sand, wave erosion of rock outcrops, and other natural processes.

But the best-known reefs are the coral reefs developed through biotic processes dominated by corals (marine organism) and calcareous algae.

Coral Reefs

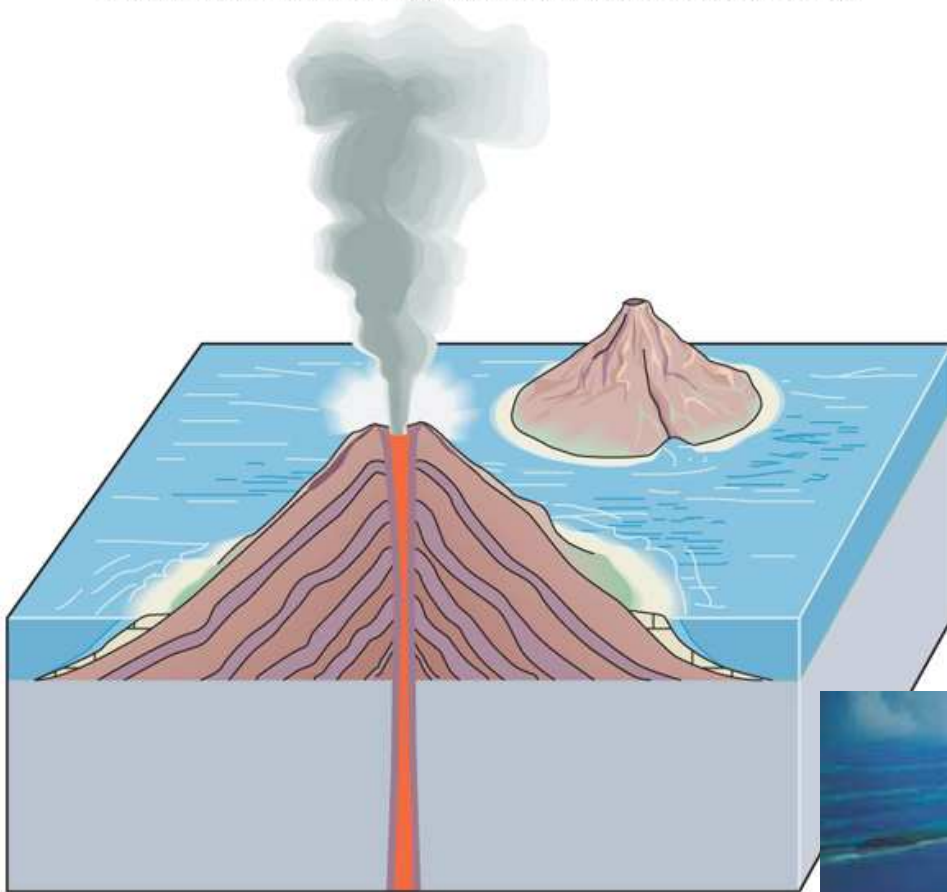
Reefs are wave-resistant ridges of coral and other calcareous organisms that may encircle islands (*fringing reefs*), parallel coastlines (*barrier reefs*), or rim circular lagoons (*atolls*)

Fringing reefs: Attached directly to the shore (Ex: Hawaiian Reef)

Barrier reefs: Parallel to the shore but are separated from it by wide deep lagoon (Ex: Great Barrier Reef, Australia)

Atolls: Atolls are circular reef that rim lagoons. They are surrounded by deep water. The diameter of atoll varies from 1km to 100 km (Ex: Bikini Atoll, South Pacific)

Fringing reefs

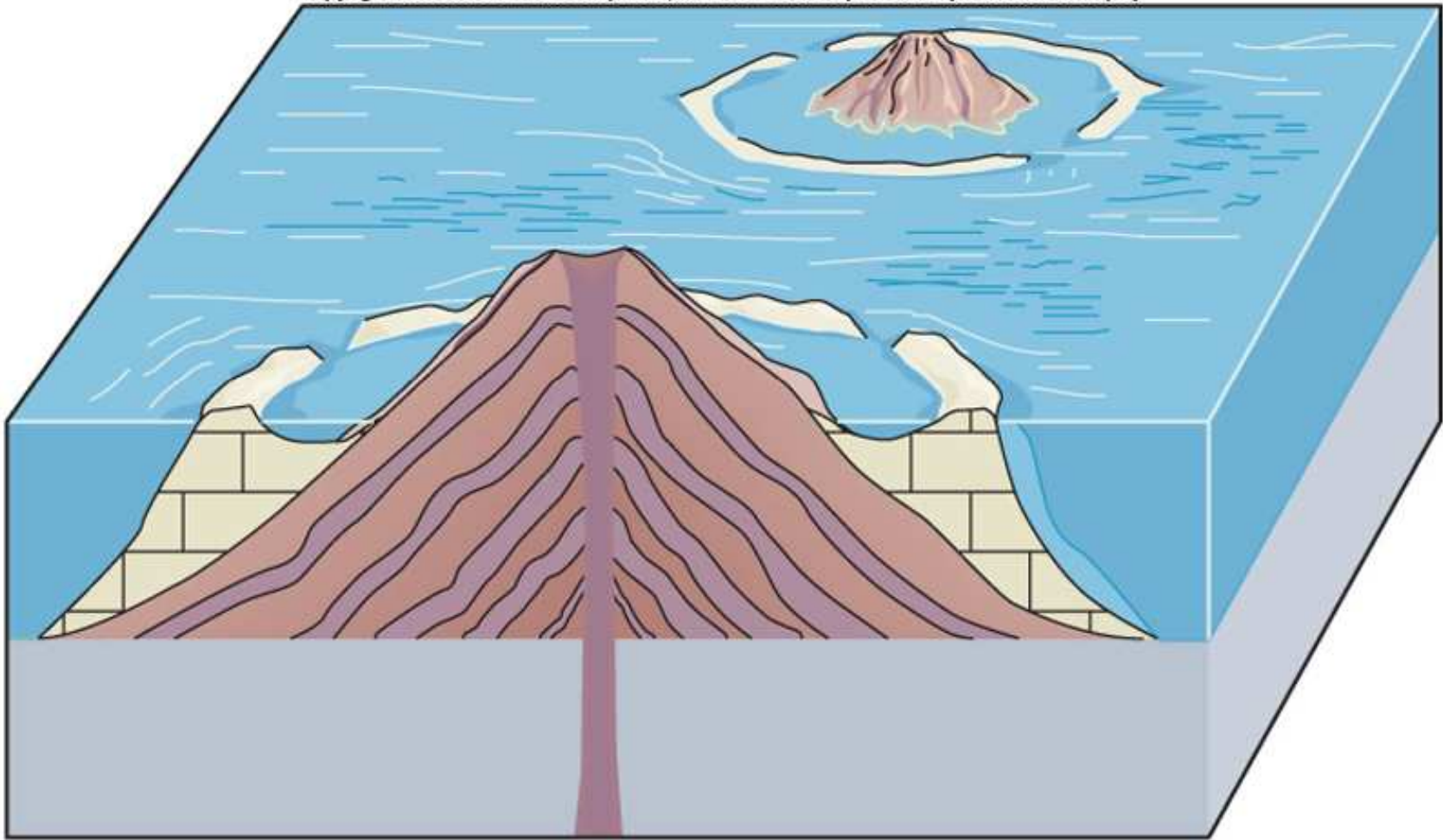


A



Barrier reefs

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B



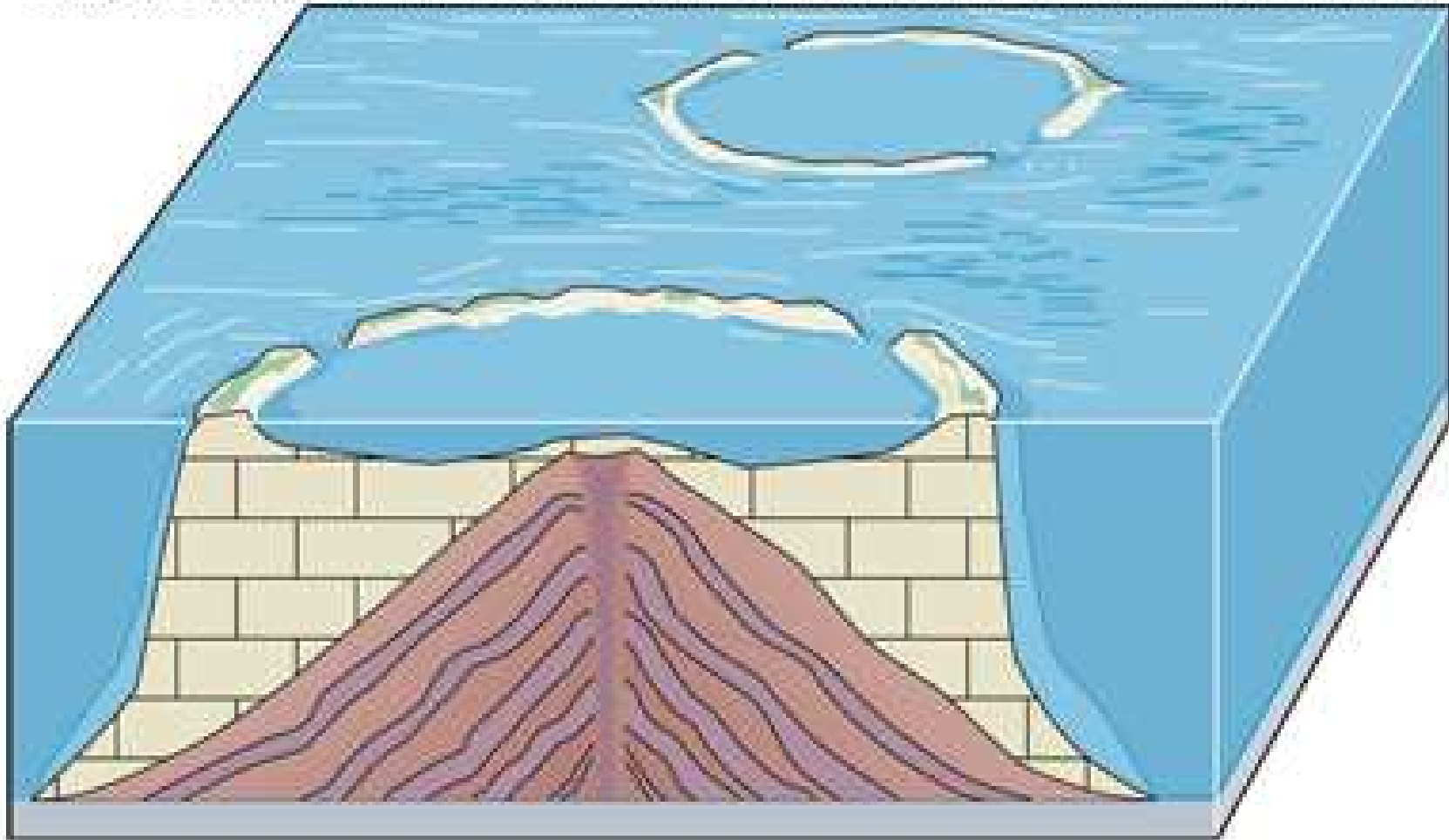
Satellite image of part of the Great Barrier Reef adjacent to the Queensland coastal areas. Credit: NASA

River Plumes Threaten Great Barrier Reef



Atoll

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C



An atoll in the Pacific Ocean (From: spaceimaging.com)

Bikini Atoll

Site of 20 nuclear weapons tests between 1946 and 1958, including the first test of the hydrogen bomb in 1952.



My coral reef research

Coral Reefs Research in Nebraska???



Nebraska

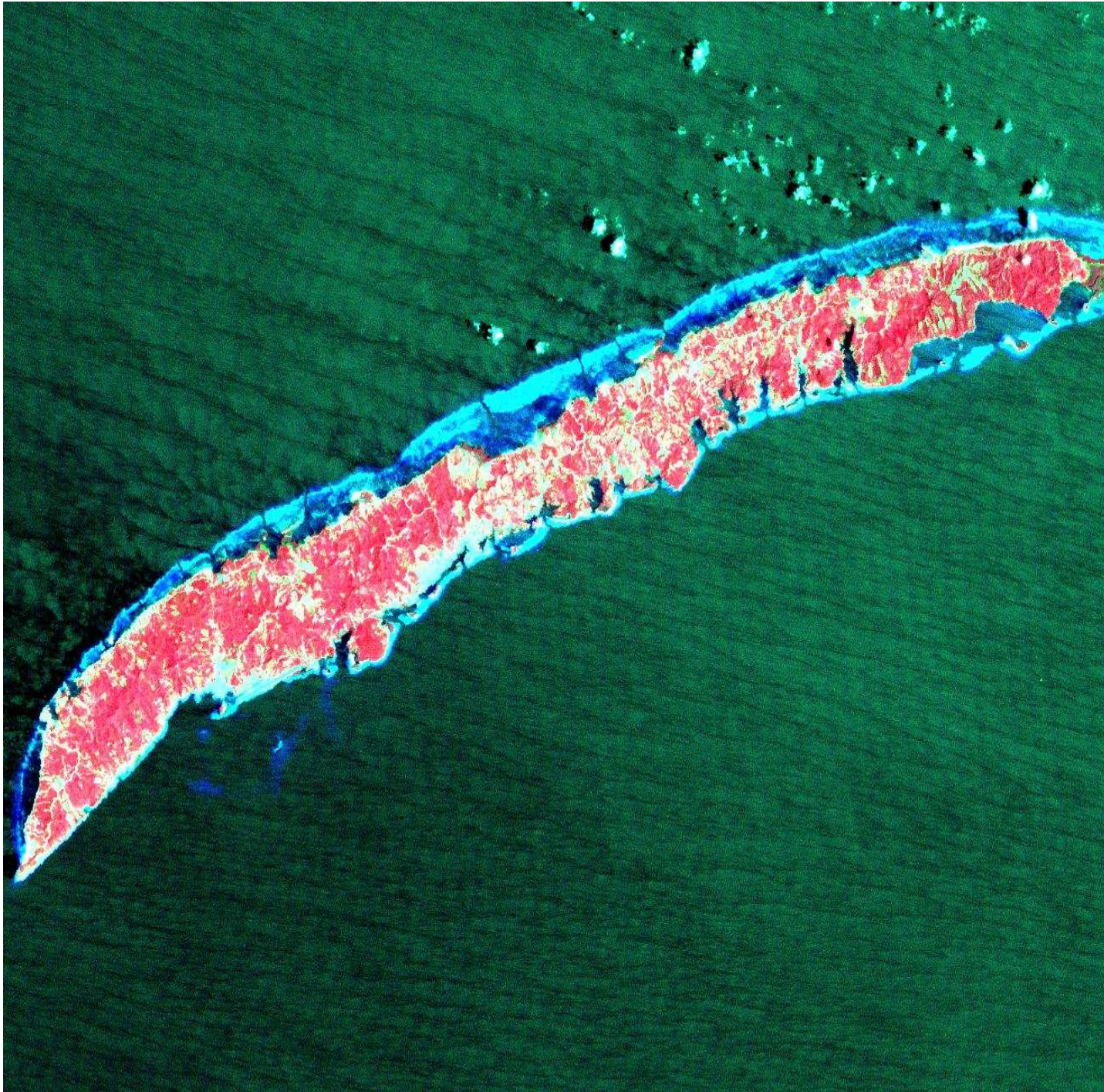


Not Nebraska



Caribbean Coral Reefs

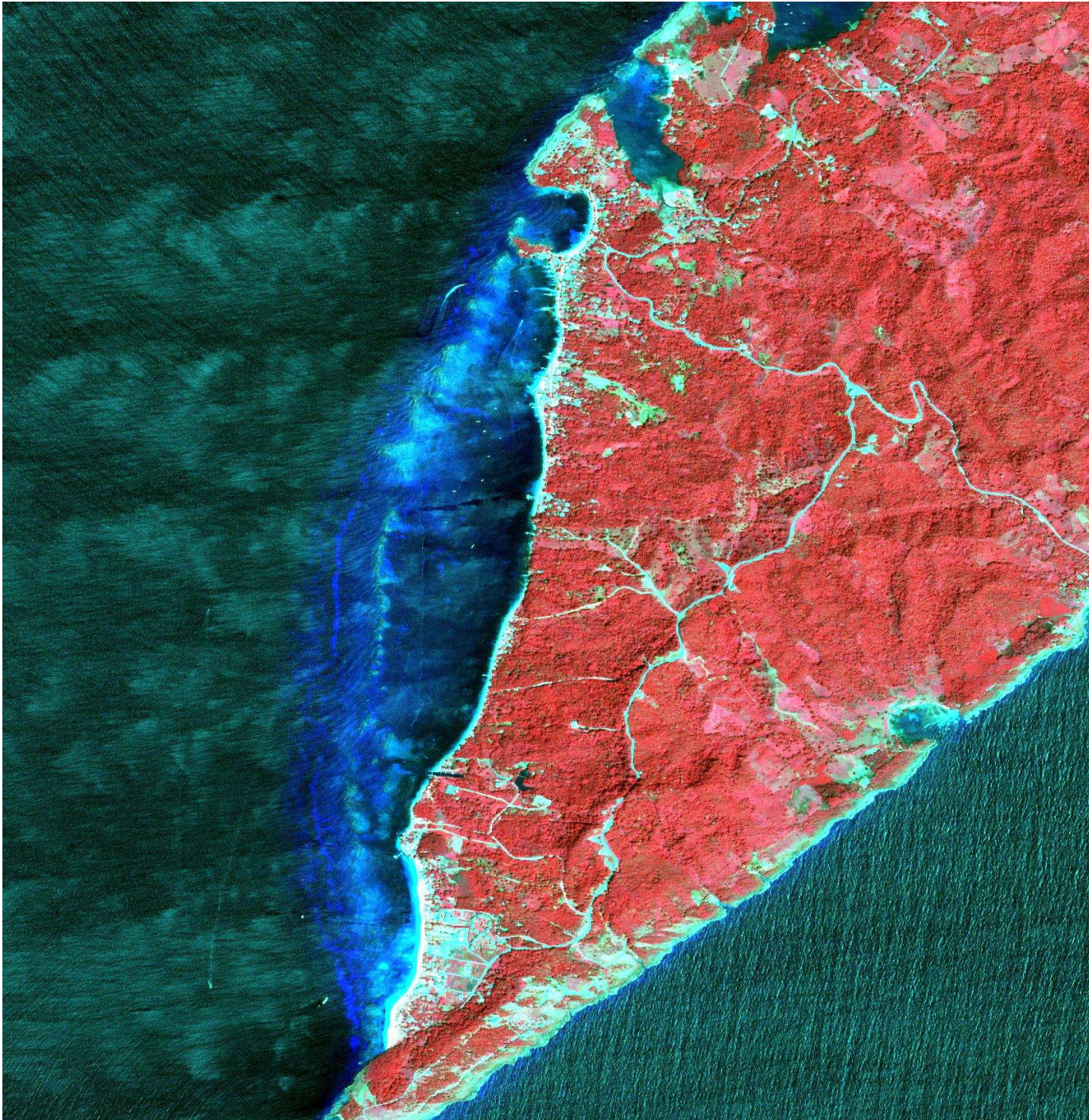




Landsat 7

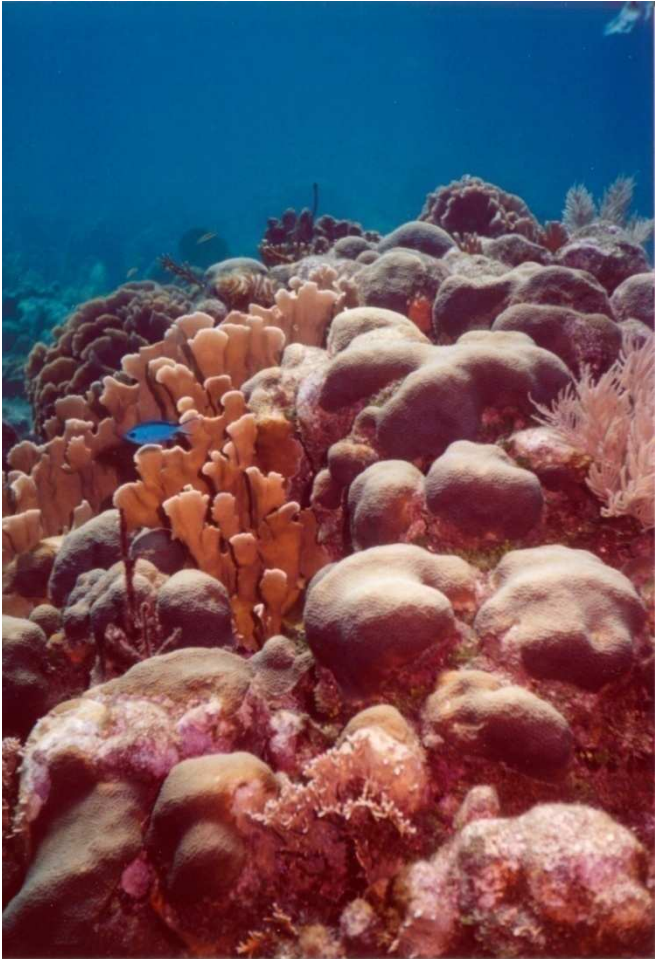


IKONOS



QuickBird

Coral Conditions



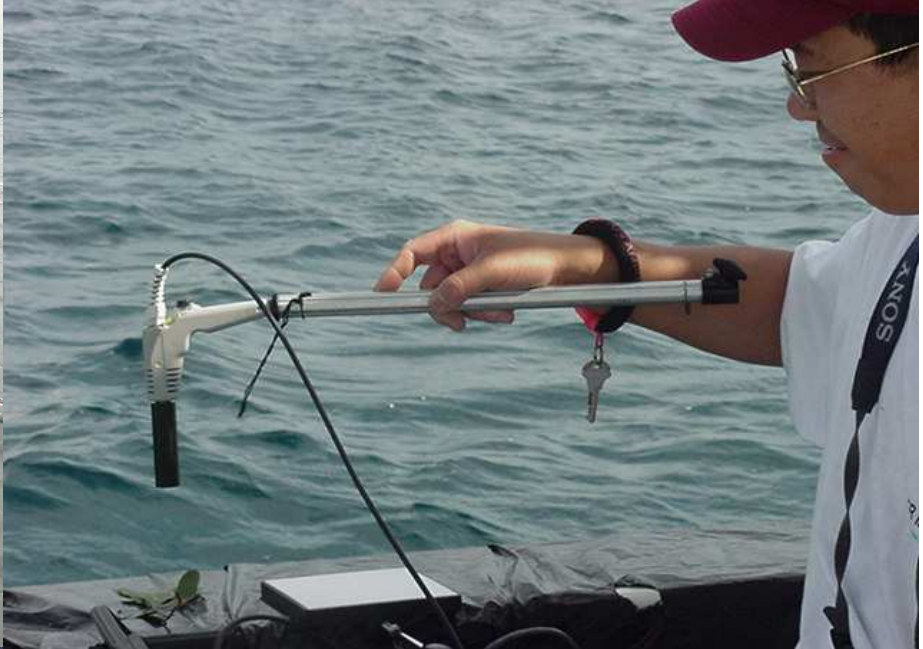
Live Coral



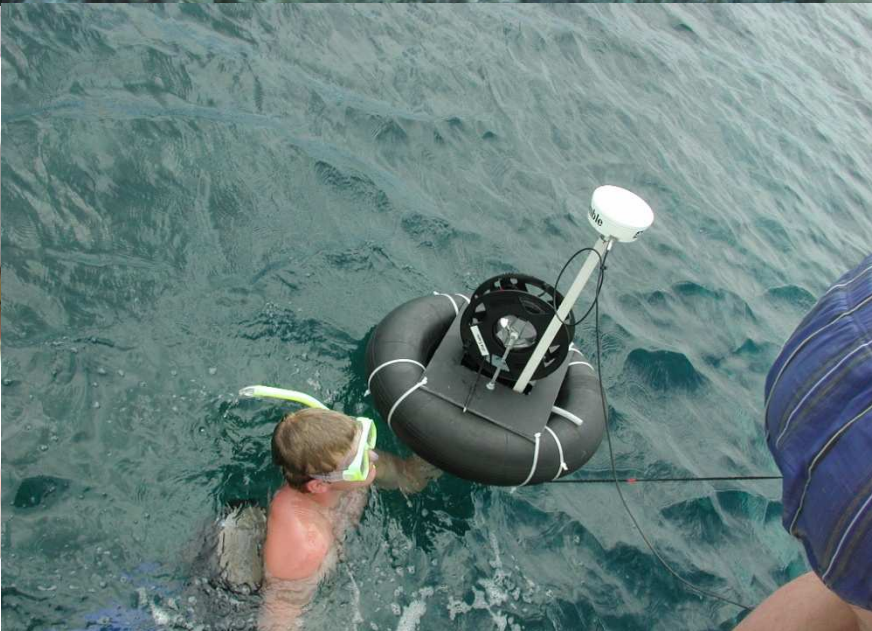
Dead Substrate

Measurement Platform: Diver

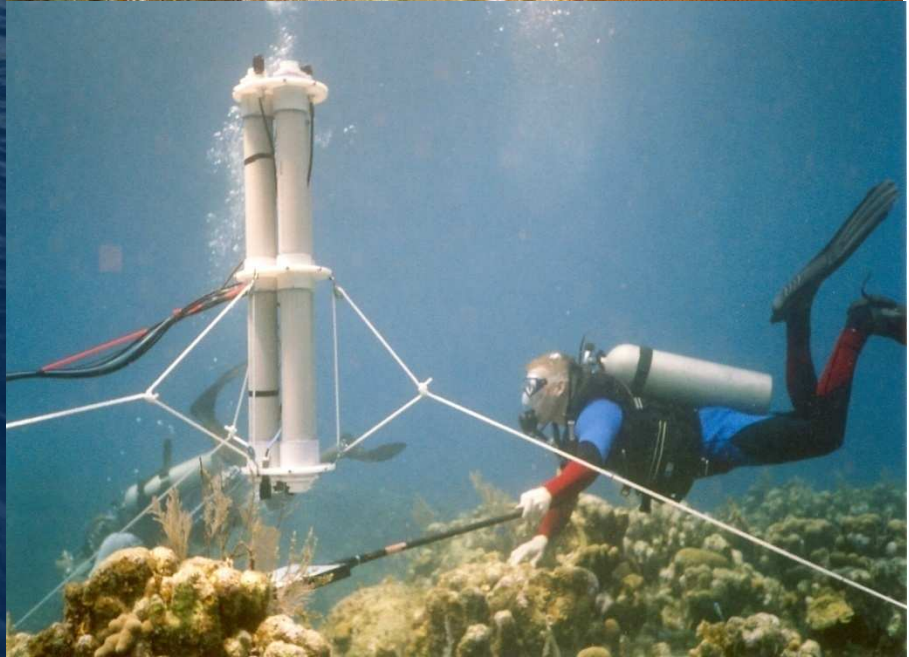
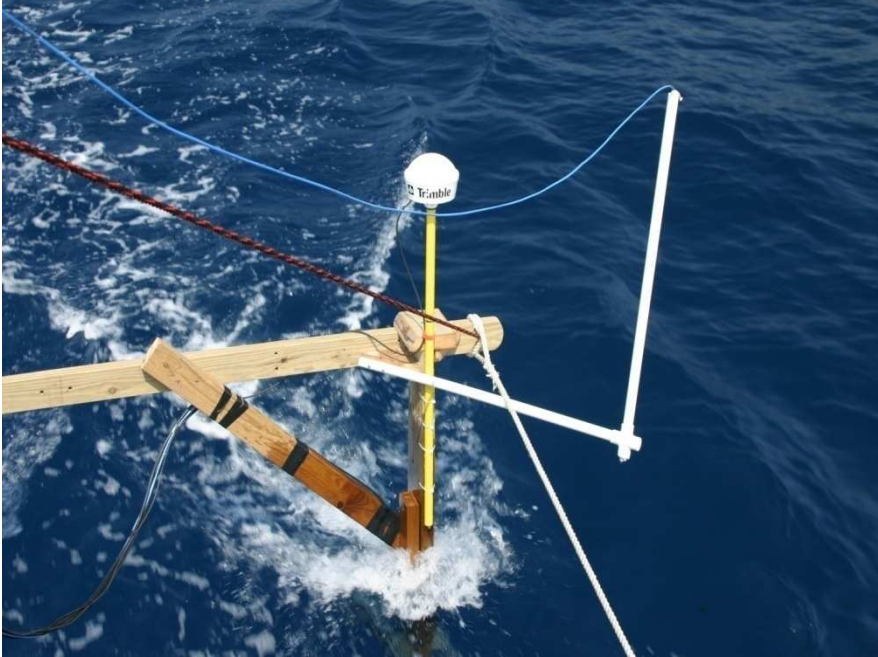




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5



Towfish Images

Seagrass with Sand



Coral



Sand



Seagrass



Coral with Sand



Coral



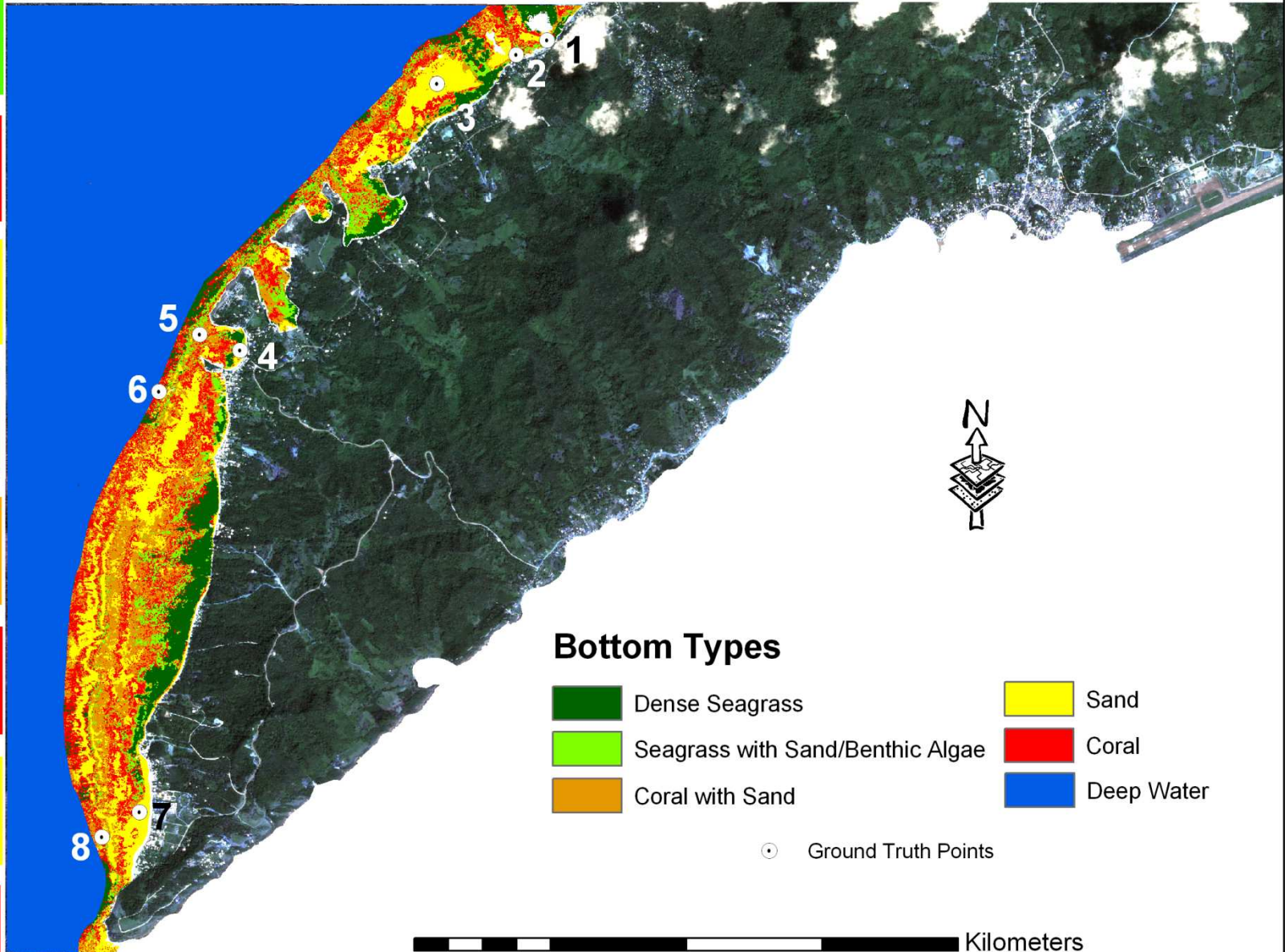
Sand









Coral




Benthic Habitat Map



Bottom Types

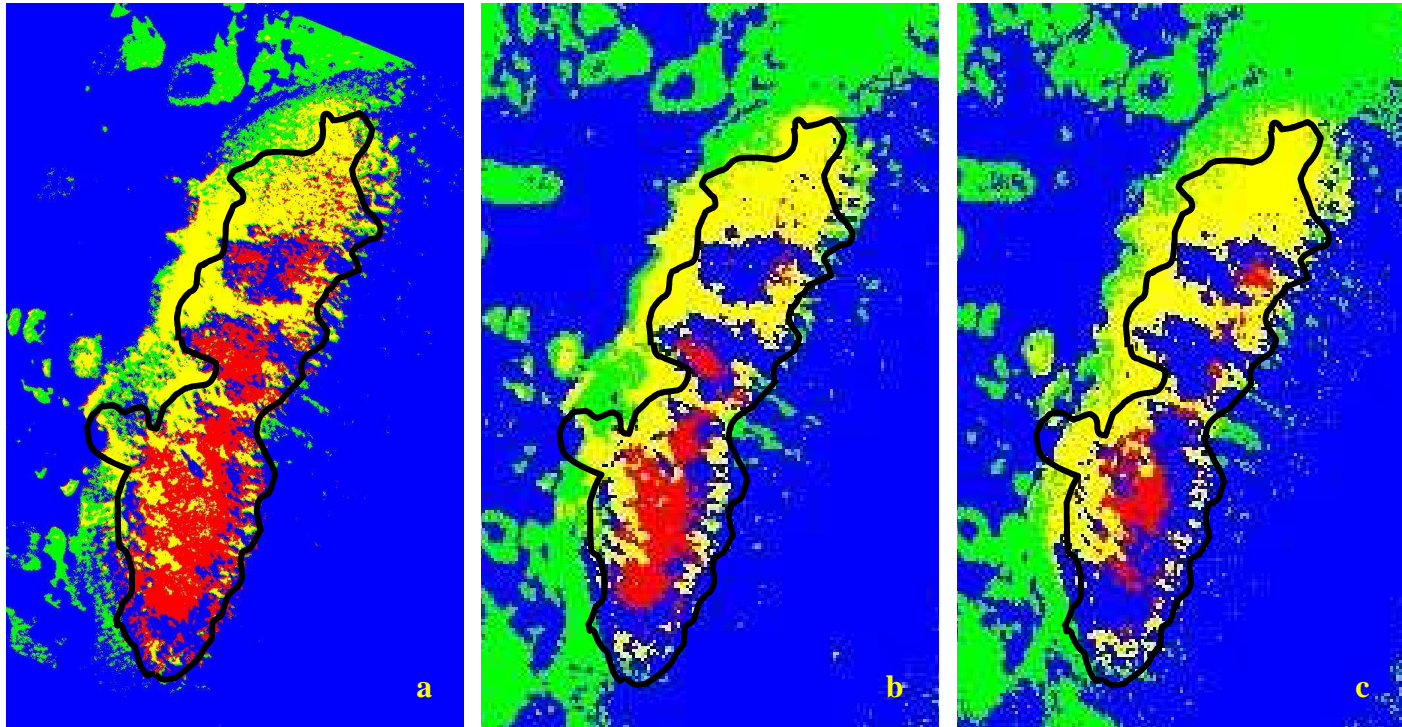
- | | |
|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
|  Dense Seagrass |  Sand |
|  Seagrass with Sand/Benthic Algae |  Coral |
|  Coral with Sand |  Deep Water |

 Ground Truth Points

 Kilometers
0 0.5 1 2 3 4

Monitoring Percent Live Coral: Why Important?

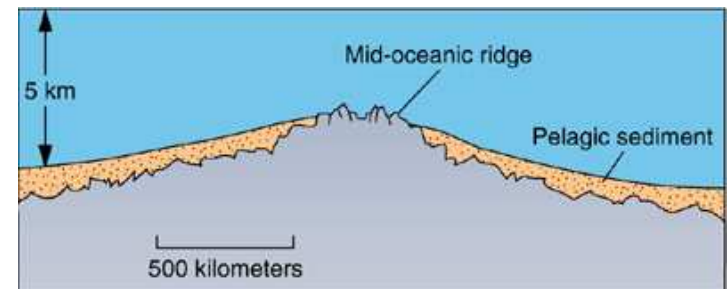
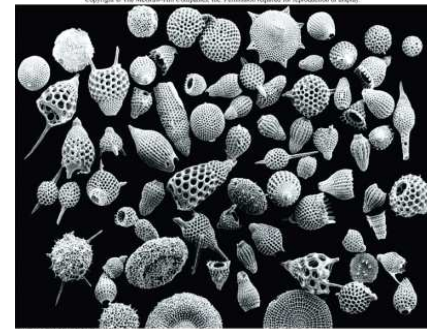
- Change detection is important in assessing global trends



Red color = live coral trend, Key Largo, FL from 1982 to 2000

Sea Floor Sediments

- Sea floor sediments may be either *terrigenous* or *pelagic*
- *Terrigenous sediments* are land-derived sediments that have found their way to the sea floor
- *Pelagic sediments* settle slowly through the ocean water, and are derived from fine-grained clay (delivered primarily by wind) and skeletons of microscopic organisms
 - Nearly absent on mid-oceanic ridge crests/rift valley



Age of the Sea Floor and the Theory of Plate Tectonics

- *All rocks of the deep sea floor are less than 200 million years old*
 - Continents preserve rocks up to 4 billion years old
- Explanation of the young age and *formation mechanisms* of oceanic crust is a crucial part of the *Theory of Plate Tectonics*

- **Next Class - Chapter 4: Plate Tectonics**
 - **Read Chapter 4 and Review Topics**

