Lecture 6: Deep Ocean Basins

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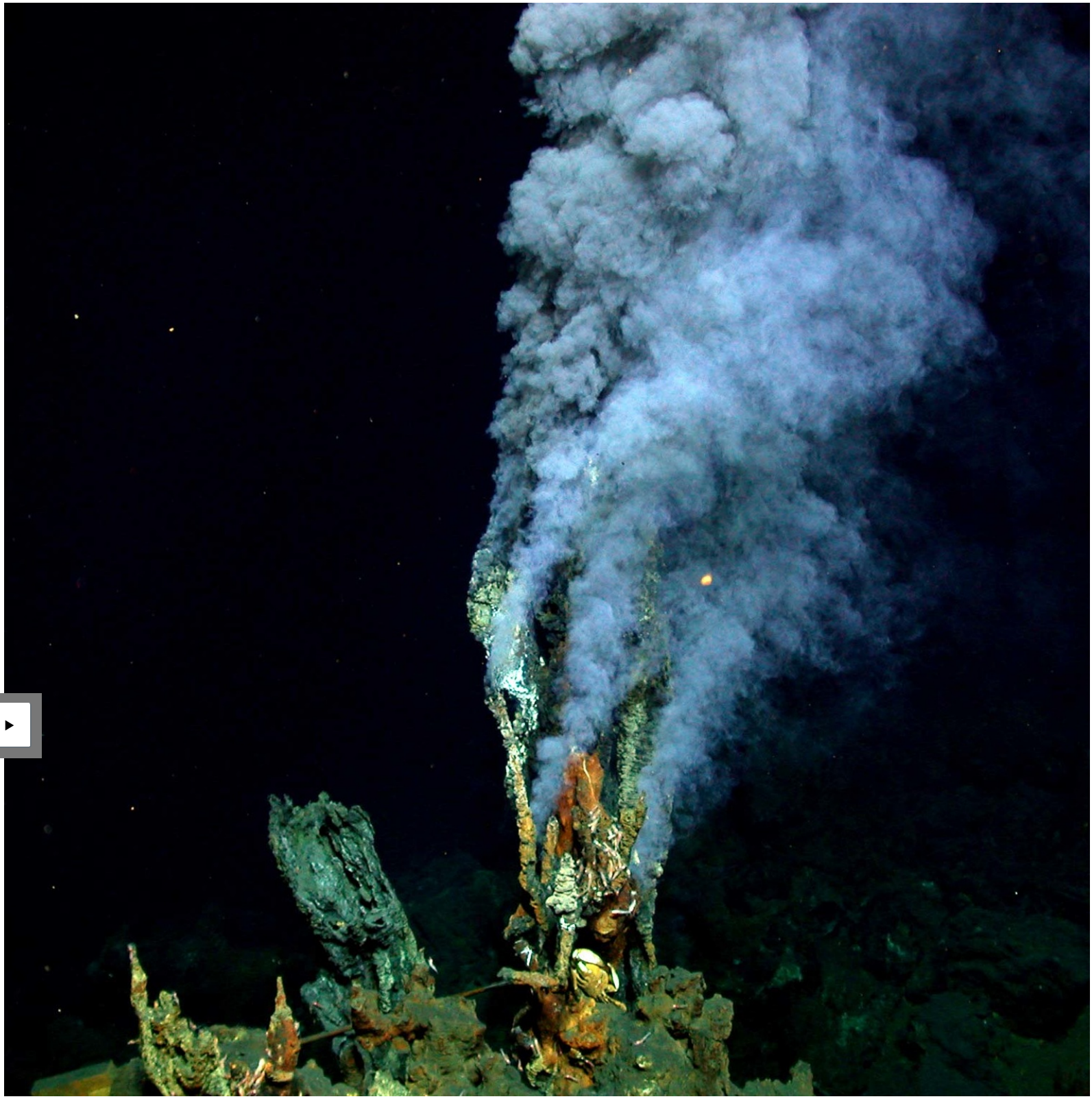
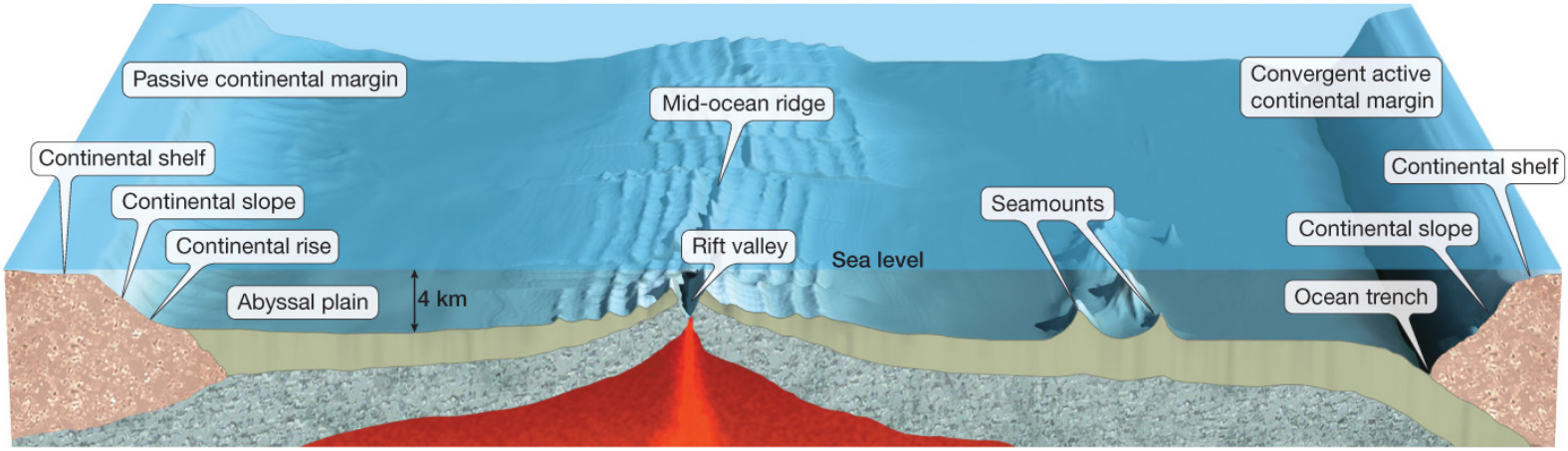
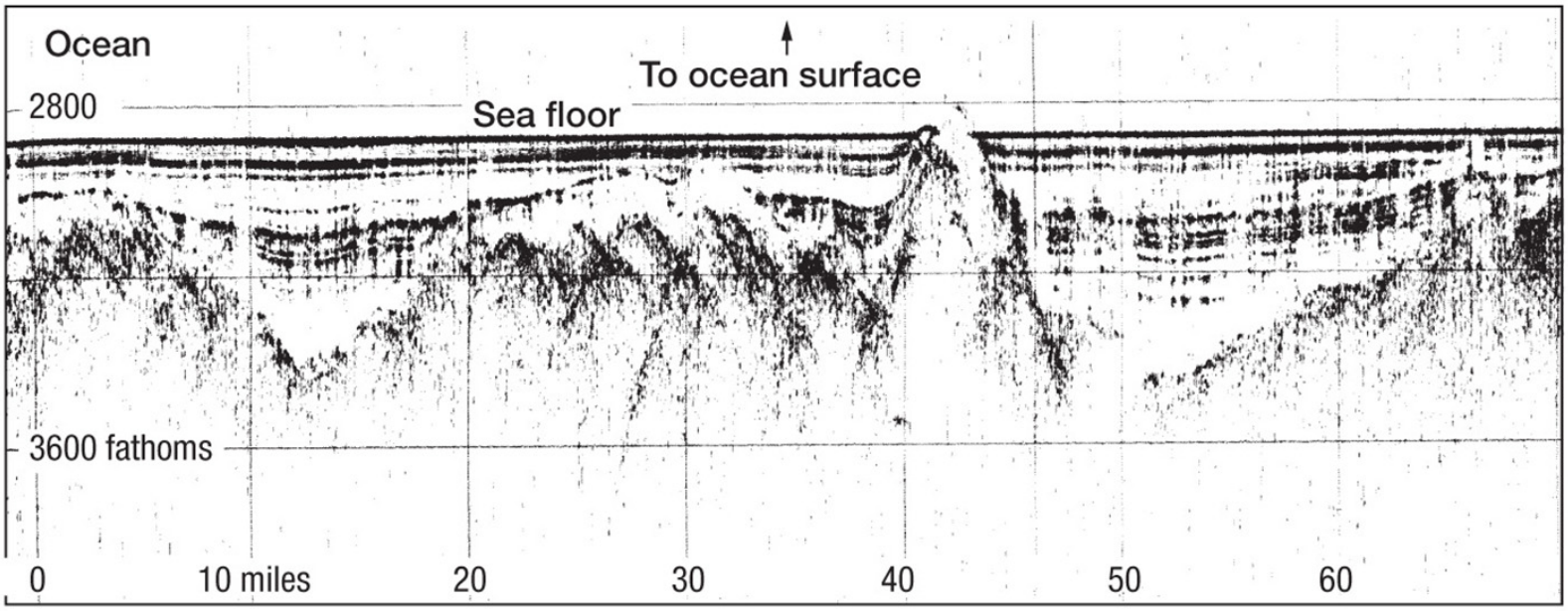
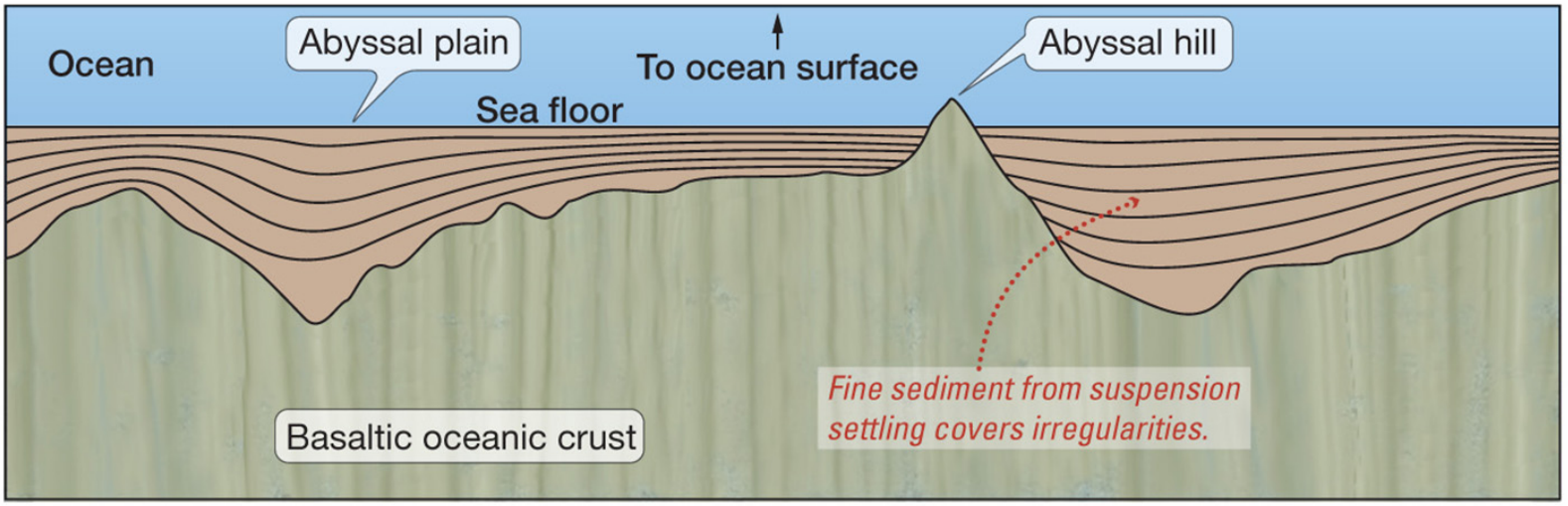


The deep ocean basin is a marine province that lies beyond the continental margin. Like the continental margin, it also contains several ocean features that we will explore now.

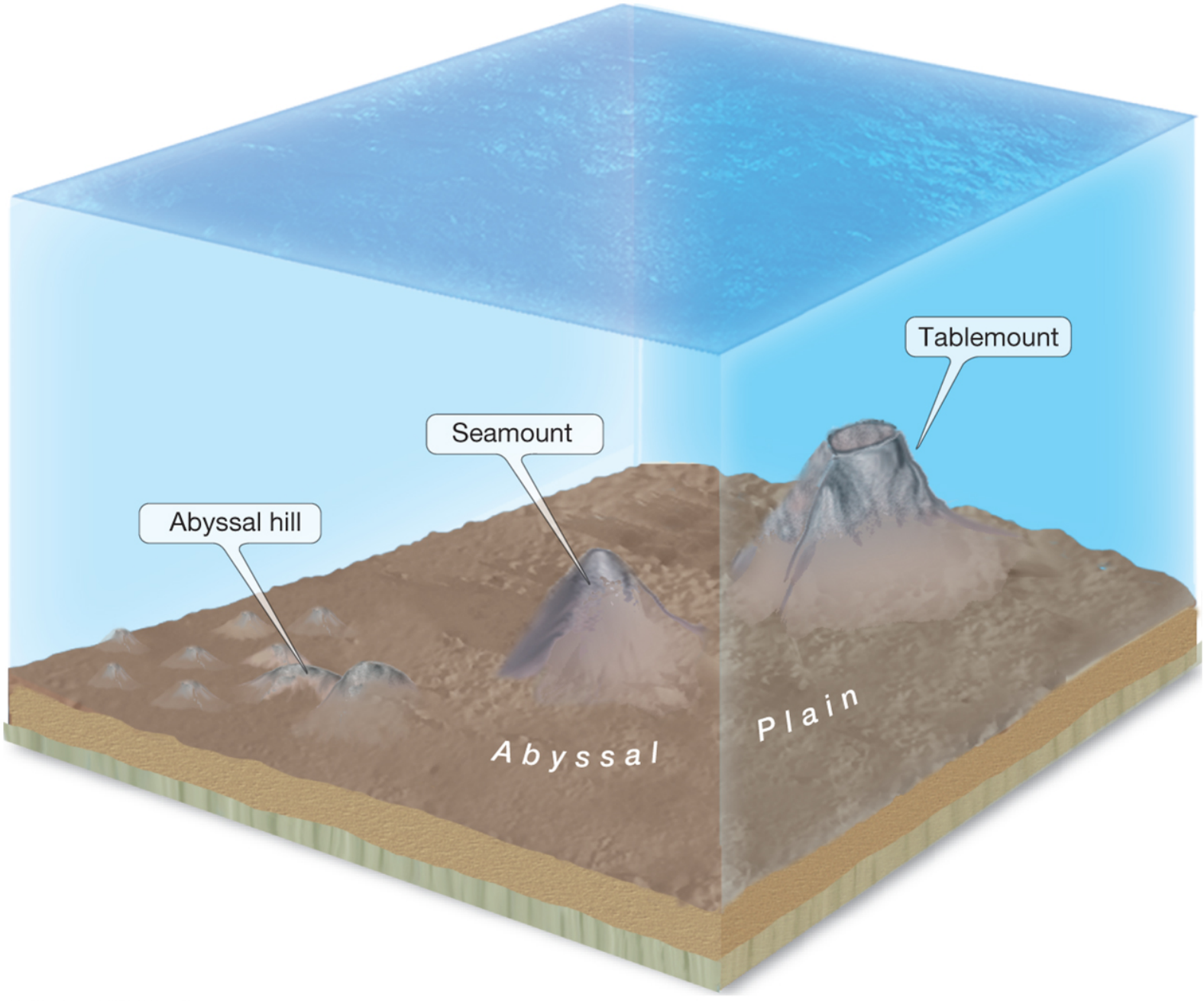


Abyssal Plains: In the deep sea are the abyssal plains. They extend from the base of the continental rise into the deep ocean, with slopes of much less than one degree (we are talking flat!). Averaging between 4500 to 6000 meters deep, the abyssal plains are some of the deepest and flattest parts of the Earth. These depositional surfaces are formed by fine particles of sediment that are slowly drifting down to the plain. Because this has been happening for so long, it has covered much of the sea floor irregularities, and the older the ocean floor, the thicker the sediment cover. The type of margin determines the nature and composition of the a given abyssal plain. Few abyssal plains are located in the Pacific. The convergent active margins in the Pacific prevent sediment from moving past the continental slope. The trenches essentially act as rain gutters.





Volcanic Peaks: Poking through the abyssal plains are a variety of volcanic peaks. Some extend above sea level, like Hawaii, while others are submerged. Peaks that rise above the surface of the ocean are called volcanic islands. When the peak rises to more than 1 km above the sea floor but remains below the surface, and is pointy on top, it is called a seamount. Current best guesses are that there are at least 125,000 seamounts in the global ocean. If the submerged peak that is greater than 1 km above the sea floor has a flattened top, it is called a tablemount or *guyot*. If the top of the peak is less than 1 km above the ocean bottom, they are called abyssal hills or seaknolls. With an average height of about 200 meters, these abyssal hills are among the most common feature on Earth.



Ocean Trenches: At active convergent (recall previous lectures about how plates interact with one another if this isn't familiar) plate boundaries, the continental slope drops off into long narrow trenches. These ocean trenches are deep channels in the ocean floor caused by the collision of the two convergent plates. On the side of the trench closest to land, volcanic arcs rise up, sometimes producing islands, like the islands of Japan, or a volcanic mountain range like the Andes mountains. The ocean trenches are the deepest parts of the world's ocean. The Challenger Deep is the deepest point on the surface of the Earth (11,022 meters deep), and it is

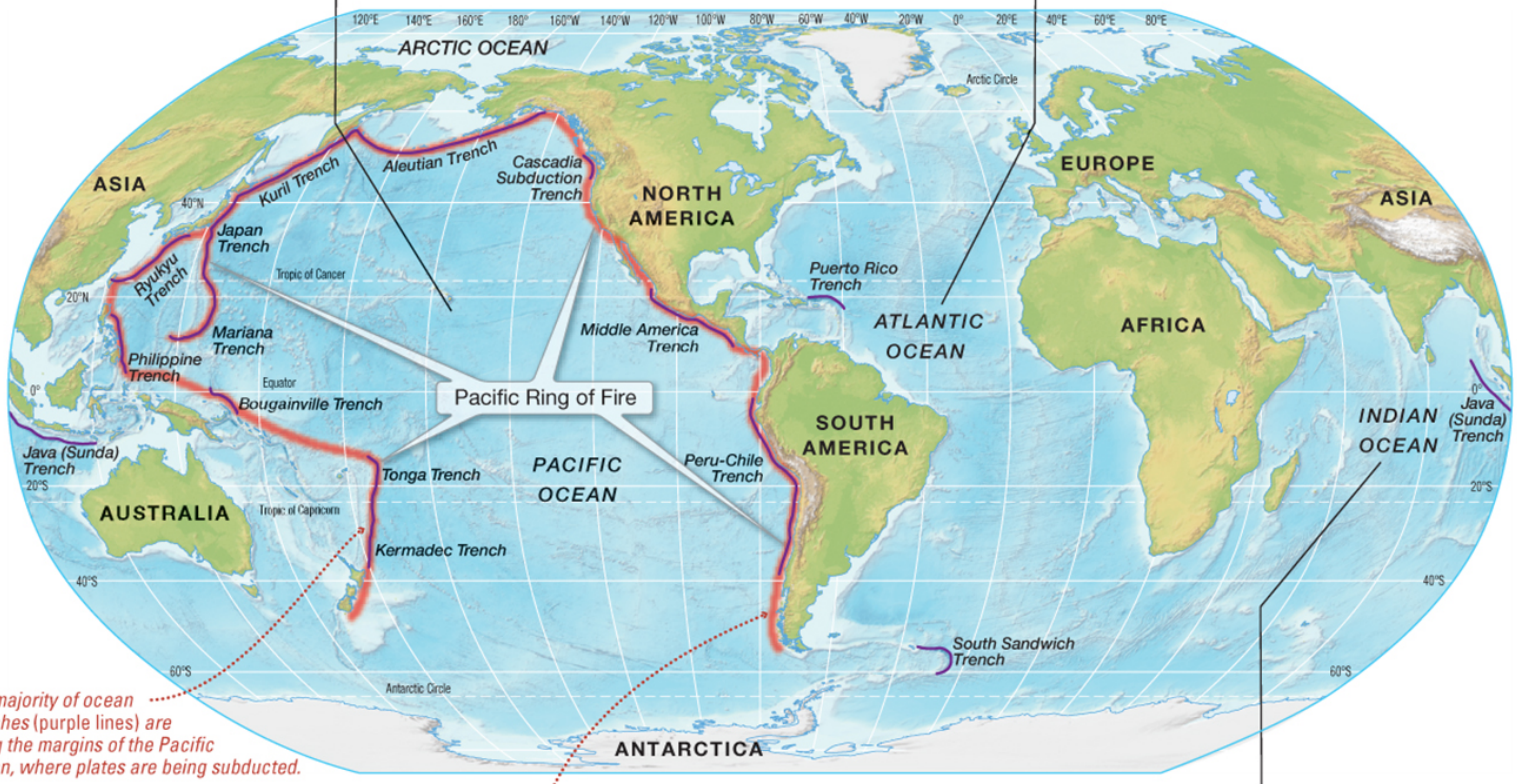
located in the Mariana Trench. Only a handful of trenches are located in the Atlantic or Indian Oceans – most of the ocean trenches encircle the edges of the Pacific Ocean in a feature called the Pacific Ring of Fire.

Selected Pacific Ocean Trenches

Name	Depth (km)	Width (km)	Length (km)
Middle America	6.7	40	2800
Aleutian	7.7	50	3700
Peru–Chile	8.0	100	5900
Kermadec–Tonga	10.0	50	2900
Kuril	10.5	120	2200
Mariana	11.0	70	2550

Atlantic Ocean Trenches

Name	Depth (km)	Width (km)	Length (km)
South Sandwich	8.4	90	1450
Puerto Rico	8.4	120	1550



The majority of ocean trenches (purple lines) are along the margins of the Pacific Ocean, where plates are being subducted.

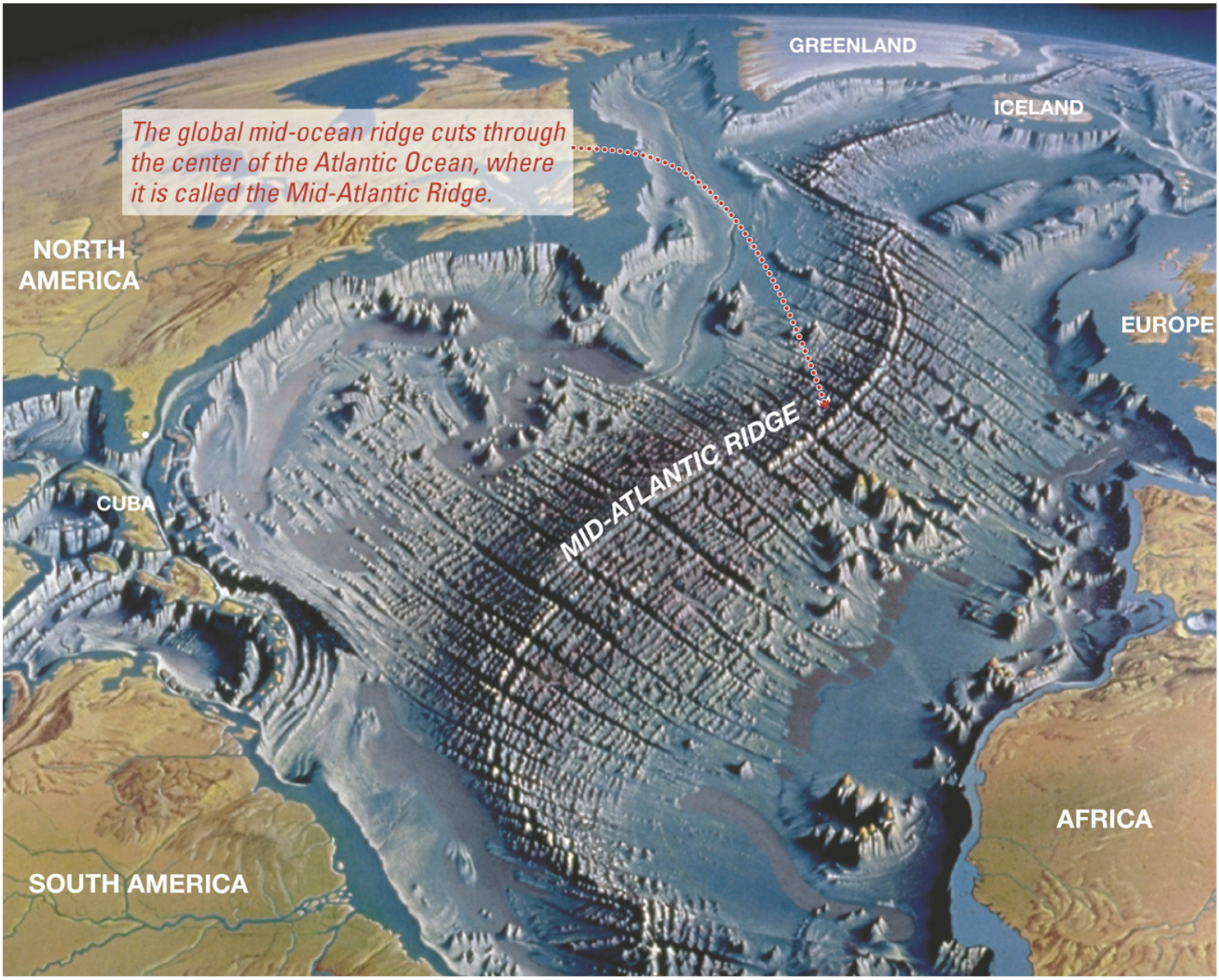
*Most of the world's large earthquakes (due to subduction) and active volcanoes (as volcanic arcs) occur around the Pacific Rim, which is why the area is also called the **Pacific Ring of Fire** (red shading).*

Indian Ocean Trenches

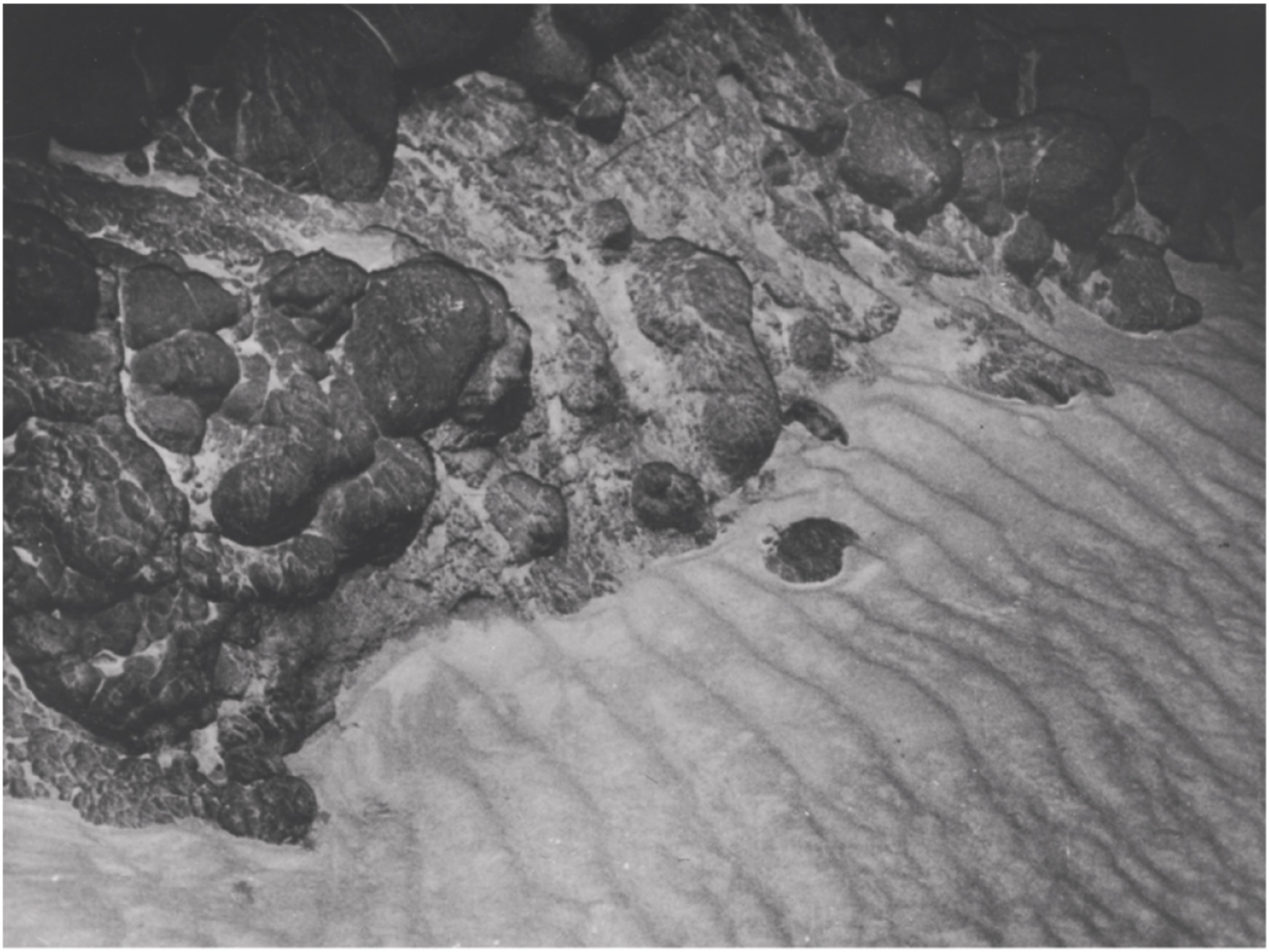
Name	Depth (km)	Width (km)	Length (km)
Java (Sunda)	7.5	80	4500

Mid-Ocean Ridge

The mid-ocean ridge is a feature we have already discussed – it is a massive, long undersea mountain range running through all of the oceans, and rising on average 2.5 km from the sea floor. At the center, a rift valley forms where the two plates diverge. Volcanoes along the ridge generate basaltic lava that forms new ocean crust. It is a massive feature, covering 23% of the Earth's surface, that largely remains underwater (only a couple of places – Iceland and the Azores – protrude above the surface). Along the central rift valley in the middle of the ridge , molten rock pushes up toward the sea floor causing earthquakes and making superheated jets of water. Let's now discuss some of the features associated with the mid-ocean ridge.



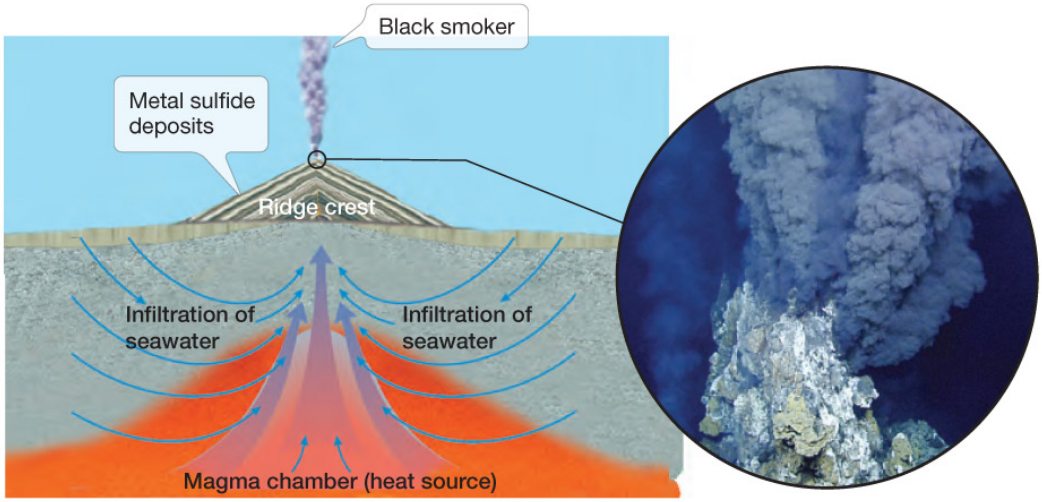
Volcanic Features: Underwater lava flows and tall volcanos are all features generated from volcanic activity at the Mid-Ocean ridge. Volcanic activity is common along the mid-ocean ridge. Each year about 12 cubic kilometers of molten rock erupts beneath the ocean - that would fill over 5 million oympic swimming pools!! Fissures (cracks) occur along the rift valley where hot magma can seep out into cold high-pressure deep ocean water. When this happens, ‘pillow lava’ (round, blob shaped rocks) are formed because of how quickly the cold water cools and solidifies the edge of the lava. Pillow lava are a common volcanic feature associated with the mid-ocean ridge.



(b) Recently formed pillow lava along the East Pacific Rise. Photo shows an area of the sea floor about 3 meters (10 feet) across that also displays ripple marks from deep-ocean currents.

Hydrothermal Vents: Hydrothermal vents occur where cold ocean water seeps into fractures in the crust and gets close enough to a hot magma chamber that the water is heated and picks up dissolved material from the rocks. The heated water then moves back toward the surface where it jets out of the sea floor. There are a few different kinds of hydrothermal vents. Warm-water vents have temperatures below 30°C, and normally have relatively clear water. White smokers have temperatures ranging from 30°C to 350°C and have white colored water due to the dissolved compounds. Black smokers have water temperatures in excess of 350°C and have black water due to dissolved metal sulphides such as iron, nickel, copper and zinc. As the hot water, laden with dissolved chemicals, escapes the crust, it encounters cold sea water that causes the dissolved chemicals to precipitate (turn back into solids), which over time create tall chimneys out of which the water flows. These vents tend to support unique sea life that has been adapted to survive in the deep ocean in the absence of

sunlight. There are giant tube worms, mussels, and clams that can use the harsh chemical environment to support symbiotic bacteria in their bodies, that they use to survive. Pretty amazing!



(a) Diagram showing hydrothermal circulation along the mid-ocean ridge and the creation of black smokers; photo (inset) showing a close-up view of a black smoker along the East Pacific Rise.

(b) Black smoker chimney and fissure at Susu north active site, Manus Basin, western Pacific Ocean. Chimney is about 3 meters (10 feet) tall.

Hydrothermal vents are an active area of ocean science. We have only studied about 200 of them so far, with many more to discover. Studying these places takes very specialized technology that can not only withstand the intense pressures of the deep ocean, but can also handle the immense heat or wild chemicals that are found at these vents. Check out **the video here about Alvin** (https://www.whoi.edu/press-room/news-release/alvin-submersible-makes-5-000th-dive/) , a deep sea submersible that has made over 5000 dives to the depths of the ocean! The way that the water is able to pick up dissolved chemicals (often metals in the case of black smokers), and then resolidify them in concentrated form at the bottom of the ocean, over geological time become important and valuable sources of mining materials. If you look at locations of metal mines in the mountain ranges along the North American coast of the Pacific, you will find remnants of ancient hydrothermal vents that are being mined today!

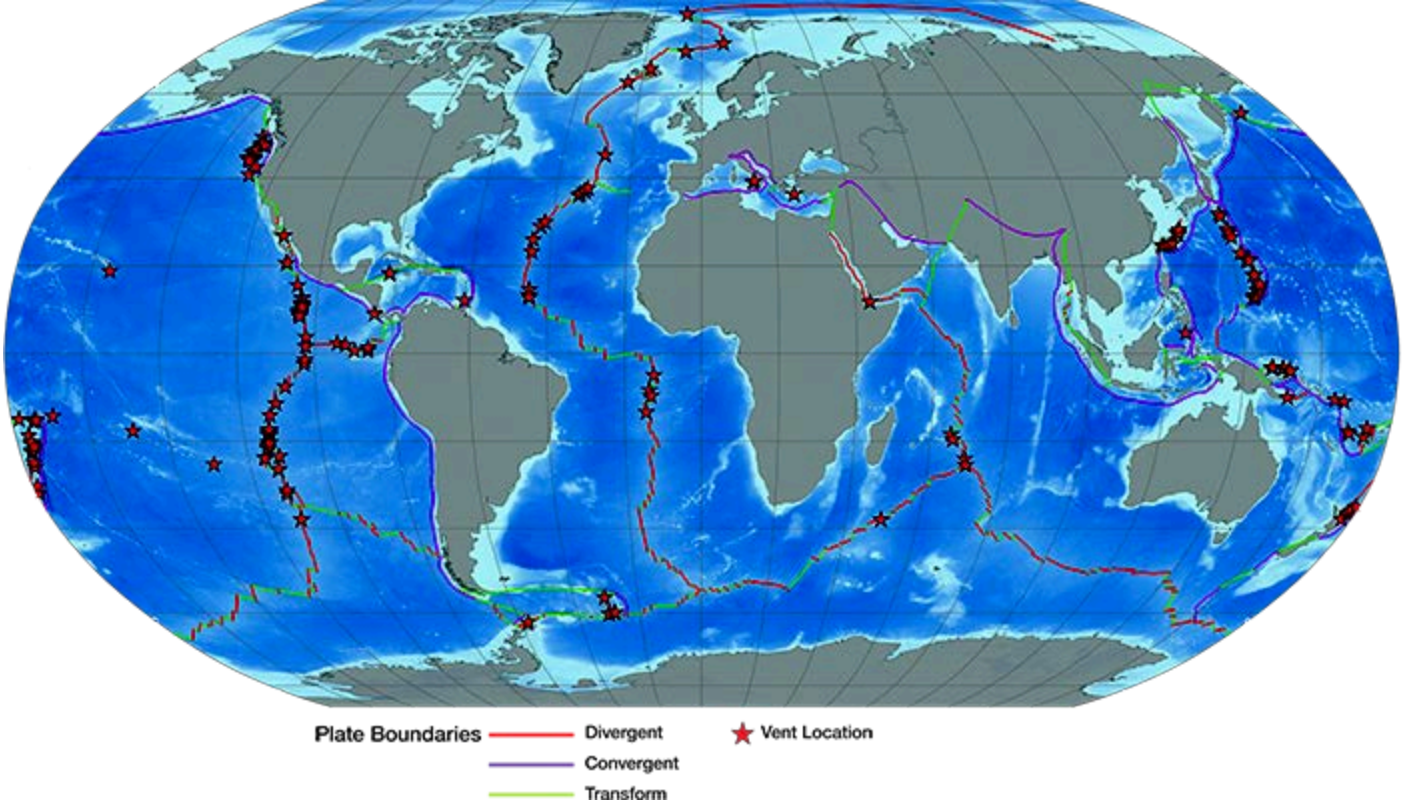


Plate Boundaries
Divergent
Convergent
Transform
Vent Location