

Discovering Plate Boundaries

Teachers Guide: Part 2 “A Tour of the Maps”

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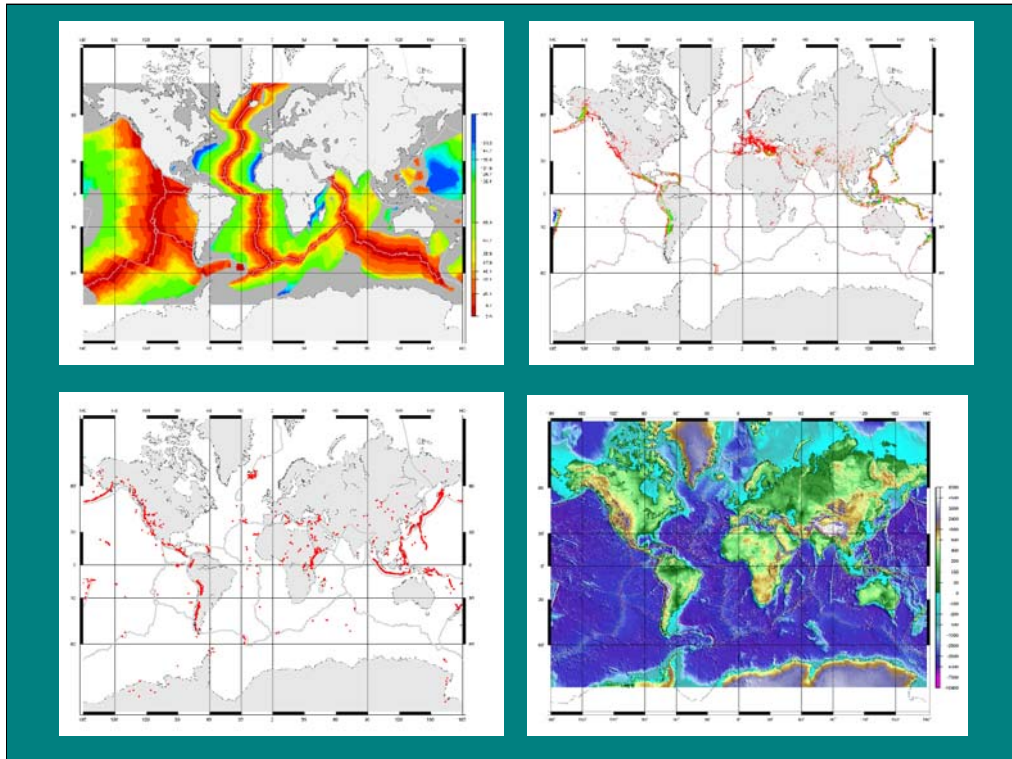


Hi, my name is Dale Sawyer. I am a Professor of Earth Science at Rice University in Houston Texas. I have worked with colleagues to develop a classroom exercise called Discovering Plate Boundaries, intended to lead students to discover for themselves the types of tectonic plate boundaries. After doing the exercise, they should be able to relate geological observations at plate boundaries to the important physical processes that occur there. This presentation is one part of the Teachers Guide I have put together to help the classroom teacher prepare to use the exercise. I hope that you find it useful. I welcome comments about the exercise and how it can be improved via my email address dale@rice.edu .

Lets begin!

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps



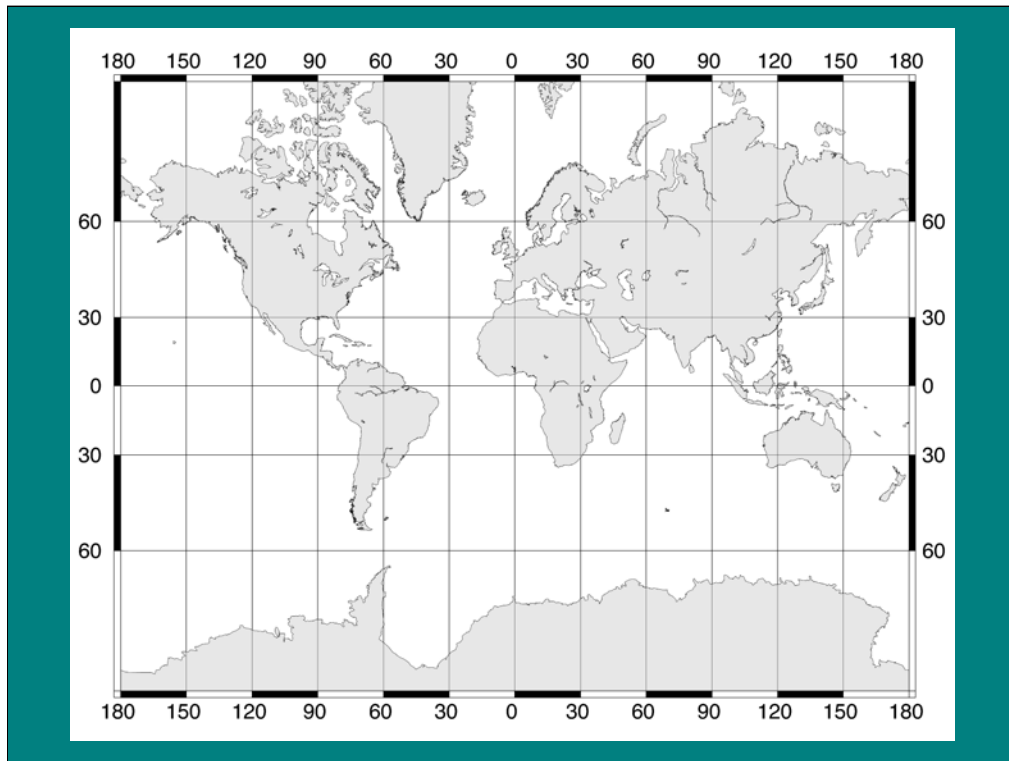
The key resource that your students will use in this exercise are four data maps. In this presentation I hope to:

1. introduce the data used in each map,
2. tell you where I got the data,
3. show you how the data are displayed,
4. show you some key parts of the data, and what your students can/should see as they complete the exercise.

The data maps used in Discovering Plate Boundaries are, a map of seafloor age, a map showing earthquake location and depth, a map showing locations of recent volcanic activity, and a map showing the Earth's topography and bathymetry.

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps



This slide contains details about the map projection. IT MAY BE SKIPPED.

The projection for all the maps in Discovering Plate Boundaries is Mercator. We chose this because it is the most commonly used projection for world maps, and your students have undoubtedly seen maps of this sort before. Other positive characteristics of Mercator maps are that north is up and east is horizontal to the right everywhere on the map, and that the graticule is rectangular so that it is easy to read latitude and longitude from the map. Less desirable characteristics are that shape and area are distorted at high latitudes (far north and south of the equator), and that the North and South poles cannot be represented because they would plot infinitely far from the equator.

You will notice that the area of a continent at high latitude, for example Greenland, is exaggerated with respect to that of a continent near the equator, such as Africa. Africa is actually much larger than Greenland! Also note that Antarctica appears huge and occupies the entire bottom edge of the map.

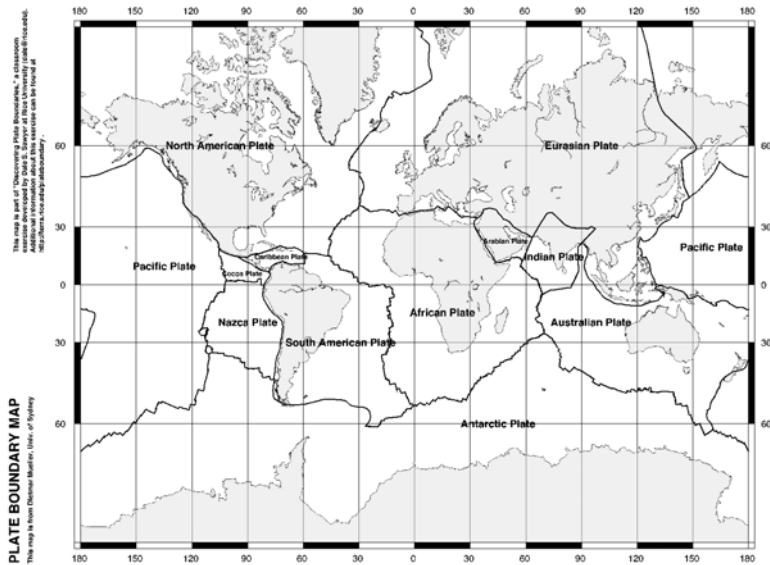
The graticule of a map is the grid of latitude and longitude lines displayed over the map. For these maps, the graticule is spaced at 30 degrees in both latitude and longitude. The lines of constant latitude run east/west and are called “parallels.” The lines of constant longitude run north/south and are called “meridians.”

The maps cover the area between 80 degrees South latitude and 80 degrees North latitude. The maps are centered on longitude 0 degrees, which is the Prime Meridian that passes through Greenwich, England. This is of course an arbitrary choice. Most students in the US have most often seen world maps centered on the US! When I was a teenager, I visited an Australian school and thought the world map at the front of the classroom looked very peculiar. After a bit of thought, I realized that it was because the map was centered on Australia and the map edges were in the Atlantic Ocean!

The coastlines are an important reference point for students. This is how they can recognize geographic locations. The coastline data for these maps include the land/ocean boundaries and the boundaries of all lakes larger than 5000 sq. km.

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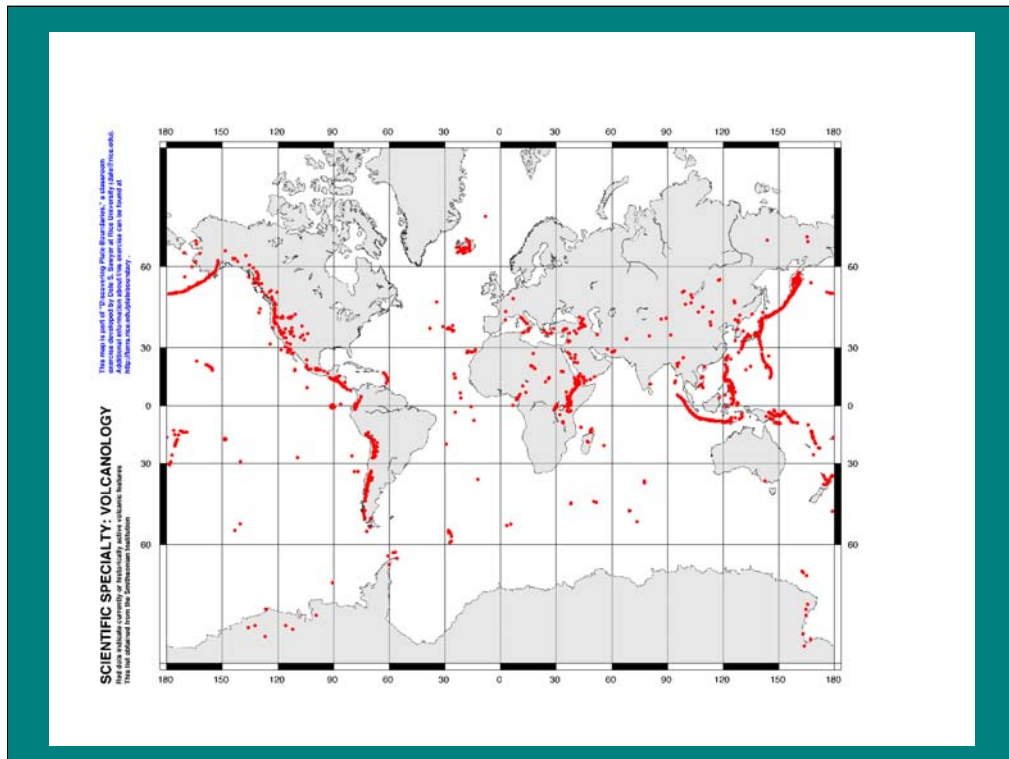


This map shows the plate boundaries that are used in the Discovering Plate Boundaries exercise. These data were obtained from Dietmar Muller, a scientist at the University of Sydney in Australia.

While most plate boundary locations are generally agreed upon by scientists, some are not. Other plate boundary maps may be expected to deviate from this one in certain details. Neither is necessarily right or wrong. To get at the differences, one must dig deeper into the observations and interpretations than is appropriate for this type of classroom exercise. Therefore, when students point out discrepancies, I praise them for their observation skills but try to lead them away from concluding that this makes the entire exercise suspect! That is simply not the case.

Discovering Plate Boundaries

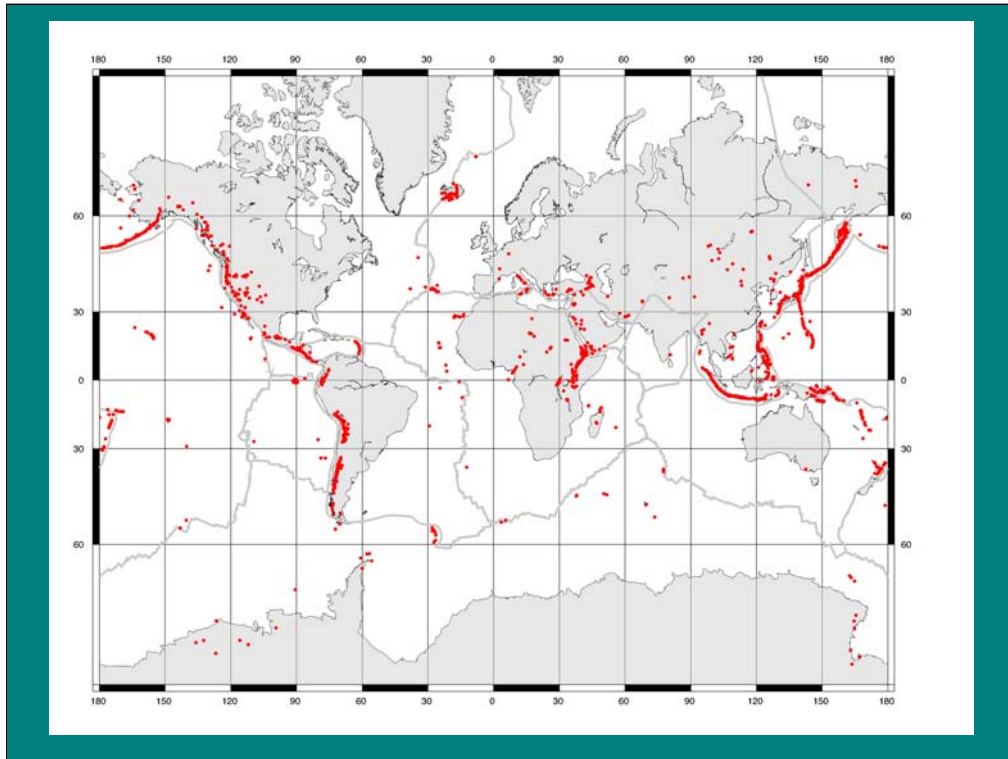
Teachers Guide 2: A Tour of the Maps



This is a small version of the map for the scientific specialty of “Volcanology.” Each red dot on this map represents some type of volcanic activity active within the last 10,000 years. Most of the dots represent volcanoes, while others represent hot springs, geysers, and other volcanic/thermal features. The data were assembled and may be obtained freely from the Smithsonian Institution in Washington, DC, USA.

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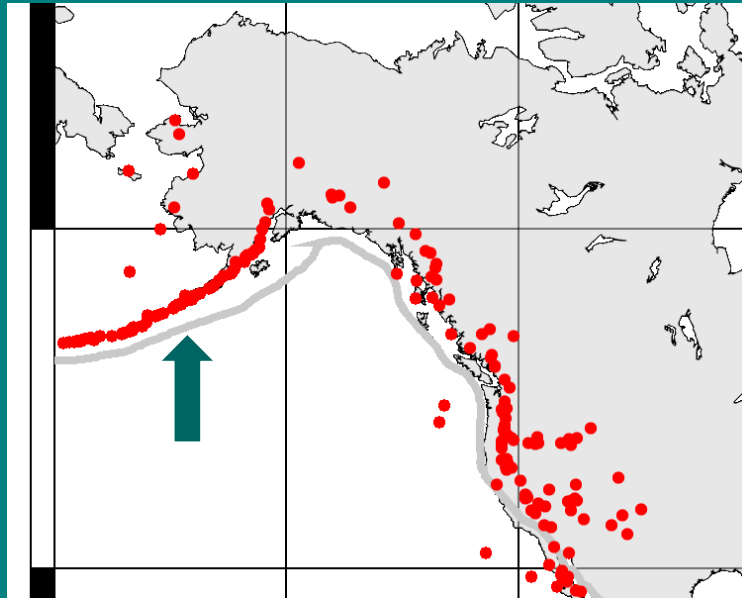


I have added the plate boundary lines (in gray) to the volcanic activity map. I will use close-up views of this version of the map to describe how volcanic features relate to plate boundaries and plate boundary processes. In this presentation, I will be emphasizing the observations that students can make. In a second presentation, I will discuss the plate boundary processes and the meaning of the observations.

You may want to use this slide in presentations to your class.

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Lines of volcanic activity are generally associated with **convergent (subducting) plate boundaries**. In these cases, the line of volcanoes is located roughly parallel to the plate boundary and generally forms a tight line. The volcanoes are located on the “over-riding” plate of the subducting plate boundary.

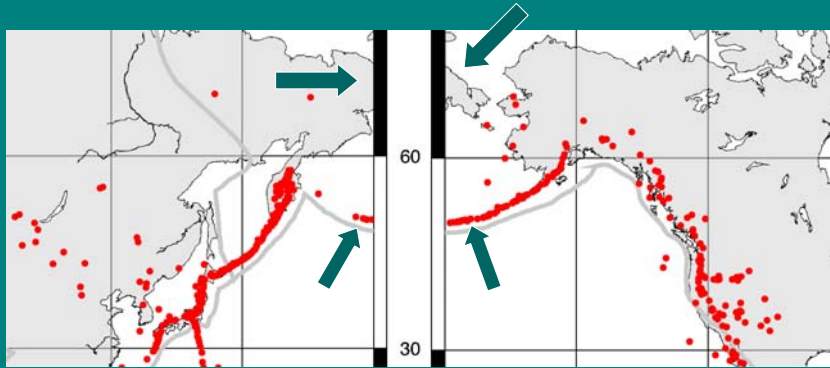
If the convergent (subducting) plate boundary is between two oceanic plates, the boundary usually has an arcuate shape. The line of volcanoes usually form a chain of islands that we call a volcanic arc. The arc is usually convex in the direction of the downgoing plate and concave in the direction of the over-riding plate.

In this perfect example of the pattern, the volcanoes shown by the arrow in this figure form the Aleutian Island Chain. The volcanoes are located in a tight line to the north of the plate boundary. The North American Plate (which includes Alaska and the Bering Sea) is the over-riding plate. The Pacific Plate is the down-going plate at this subduction system.

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Note that this kind of map wraps around at its edge!



Right side of map

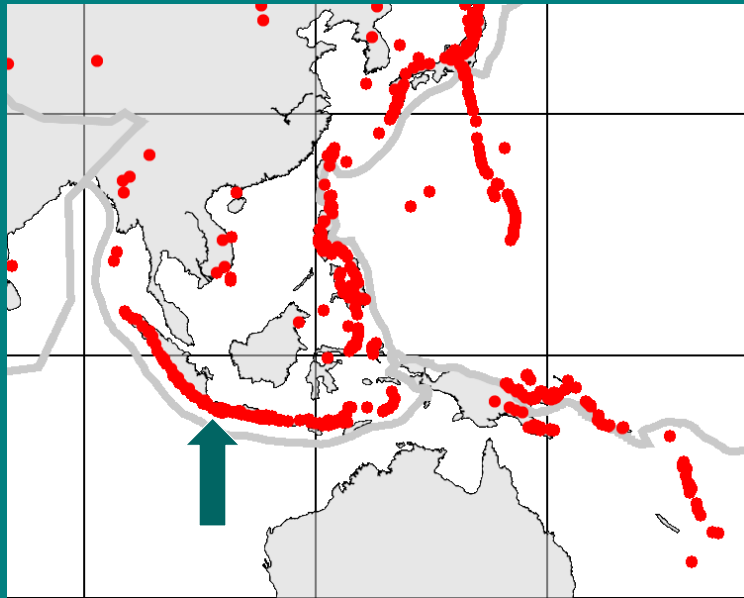
Left side of map

You may want to ask your students to note that features on the Earth sometimes cross from one side of the map to the other. The arrow pairs in this slide show that the Aleutian Island Arc and the landmass of Siberia extend across the map edges.

This would not be a problem if we were doing all our work with a globe. It is a problem when we work with flat maps.

Discovering Plate Boundaries

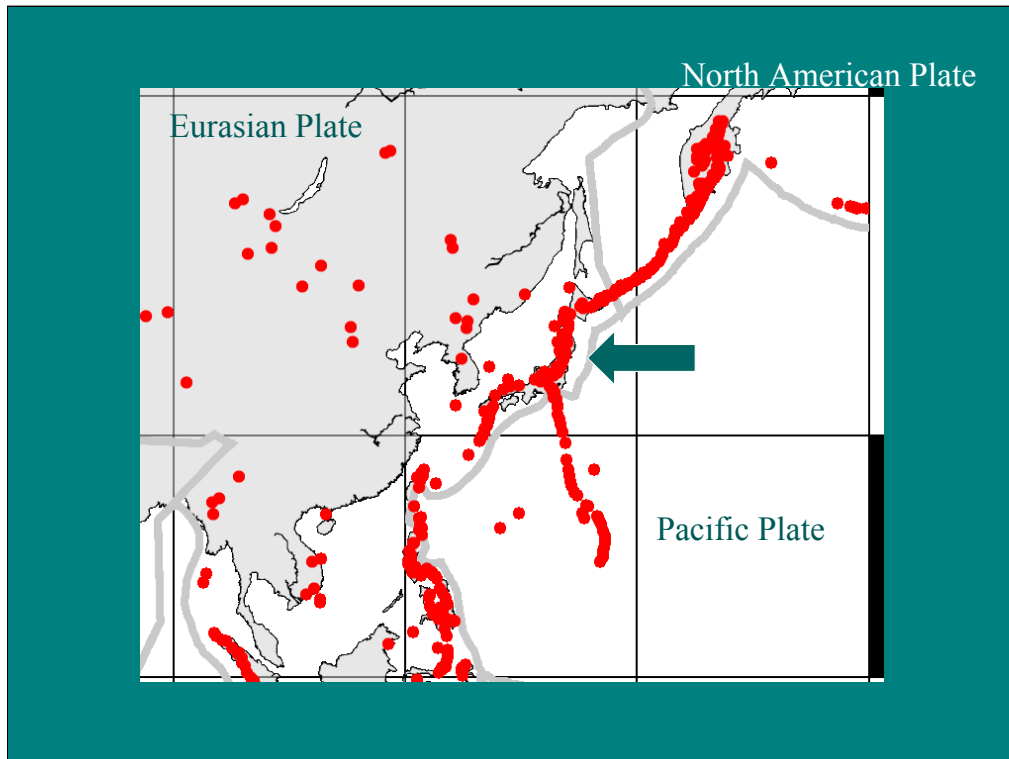
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The Indonesian volcanic arc marked with the arrow is another fine example of a Convergent (subducting) plate boundary between two oceanic plates. It has the same characteristics as the Aleutian example. As you can see, this is a very complicated part of the world (in a plate tectonic sense!).

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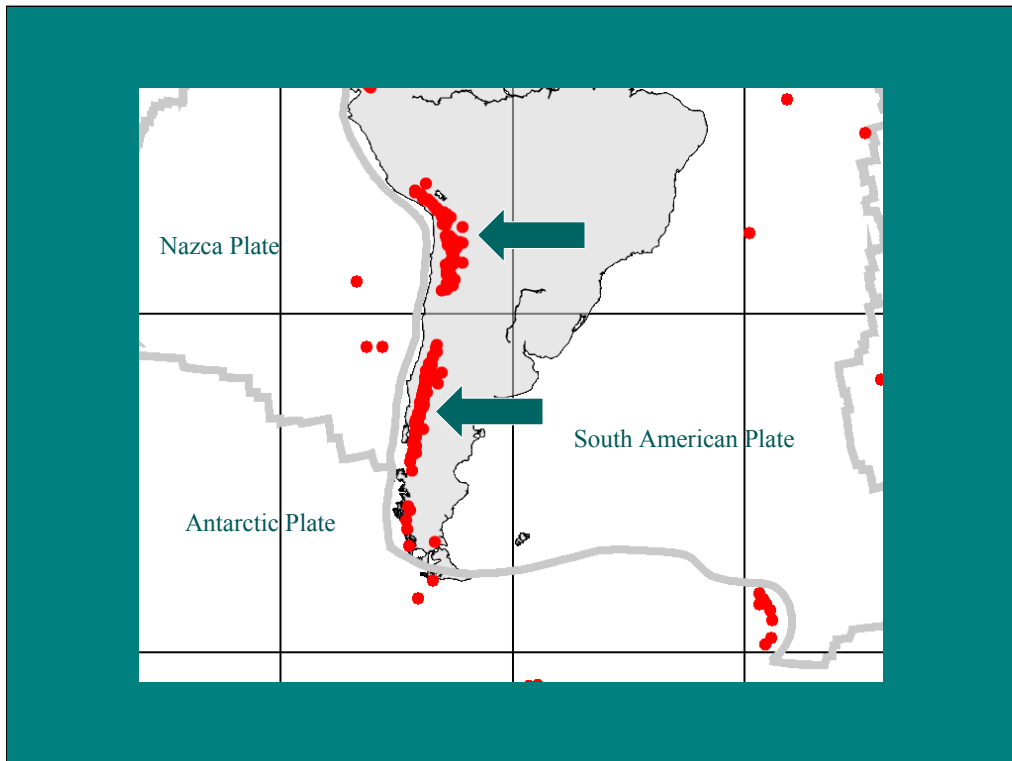


Japan, marked with the arrow, is part of a complex set of shorter subducting plate boundary segments. Note that each has the key properties I mentioned: arcuate shape and volcanoes in a tight line roughly parallel to the plate boundary. Which plate is the down-going plate in this system? Which plate is the over-riding plate in this system?

I hope you said that the Pacific Plate is going down beneath the Eurasian and North American Plates!

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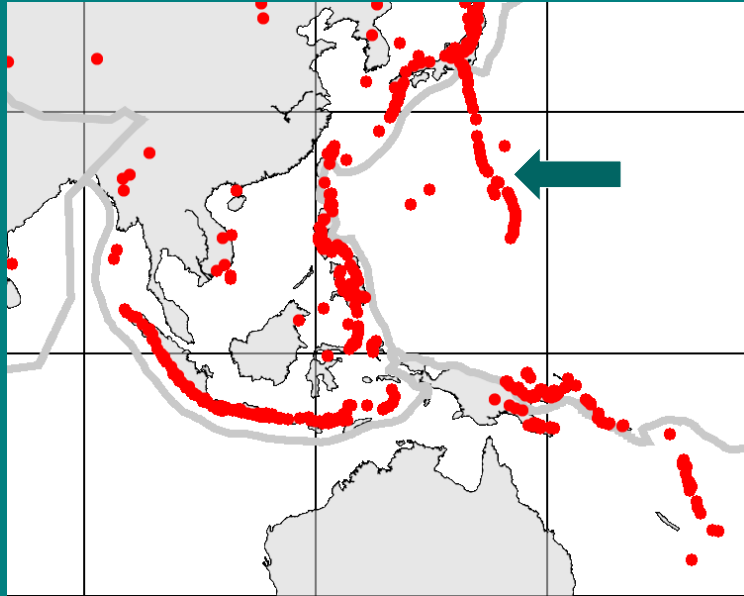
This is an example of a Convergent (subducting) plate boundary in which oceanic crust (Nazca and Antarctic Plates) is being subducted beneath continental crust (South American Plate). Note that at such a boundary, it will always be the oceanic plate as the down-going plate and the continental plate as the over-riding plate. This is because oceanic crust is almost always denser than continental crust.

Note that the main differences between this plate boundary and the boundaries we saw in the Aleutian and the western Pacific are that the volcanoes here are part of a high mountain system (the Andes Mountains) rather than an island chain, and that the arcuate shapes are often not as obviously developed. The other patterns hold, with the volcanoes in a tight line, parallel to the plate boundary, and on the over-riding plate.

Note that in the lower right hand corner of this map is a short, well developed, volcanic arc related to the westward subduction of the South American Plate under the Antarctic Plate. We call this the Scotian Arc.

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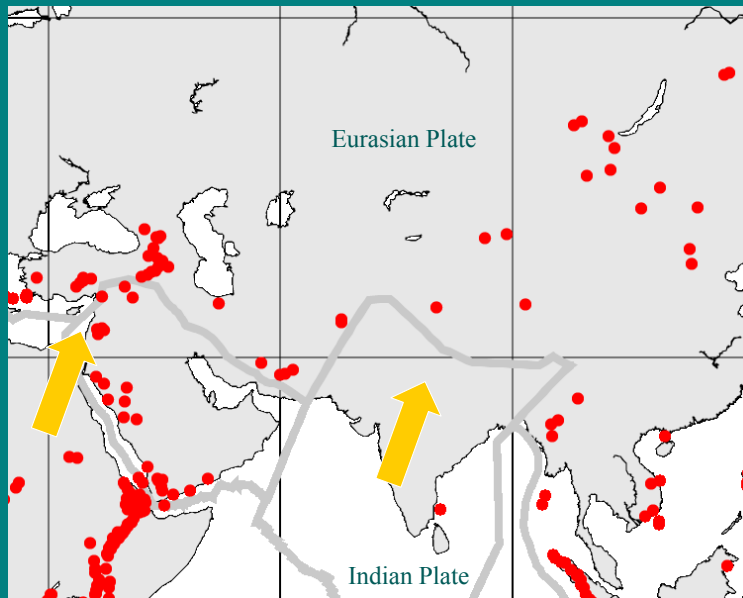
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Your students are likely to observe this line of volcanoes and ask why it does not lie along a plate boundary. The answer is that it does lie along a plate boundary, but the south end of that boundary is ill defined and poorly understood! I have therefore elected to leave that boundary out of the plate boundaries included in the exercise. The students should be applauded for their skills of observation and pattern recognition!

Discovering Plate Boundaries

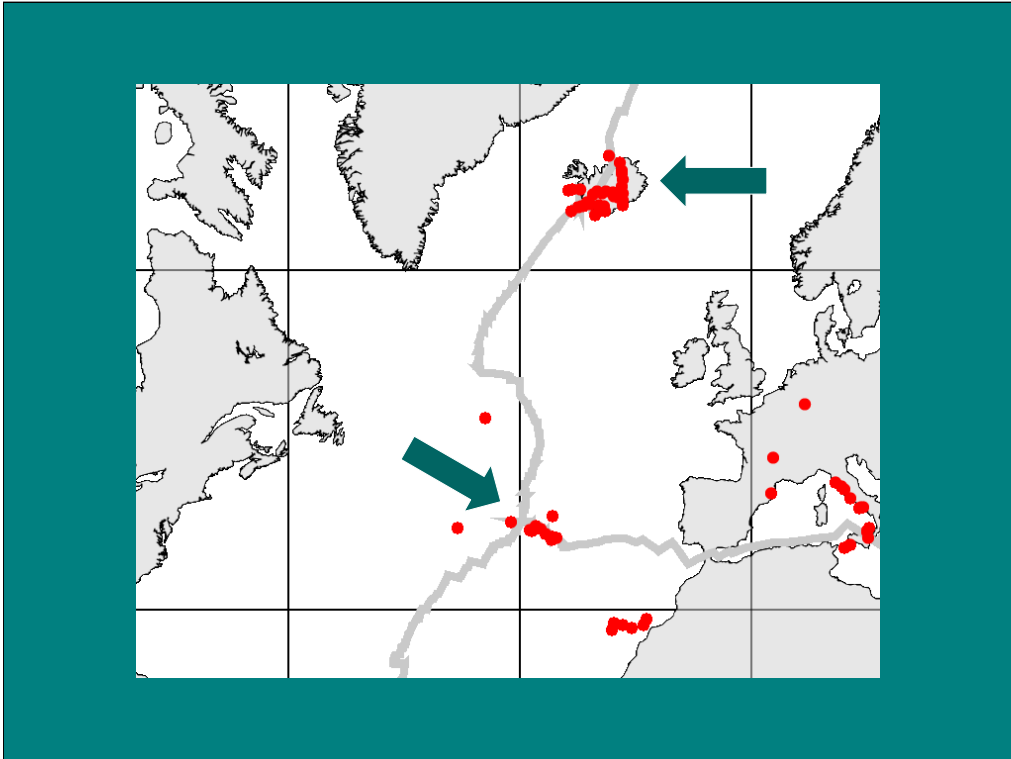
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The final type of Convergent plate boundary is at the collision of two continents. In this example, the Indian plate is colliding with the Eurasian plate. As we see here, there is often no volcanic activity associated with this type of plate boundary.

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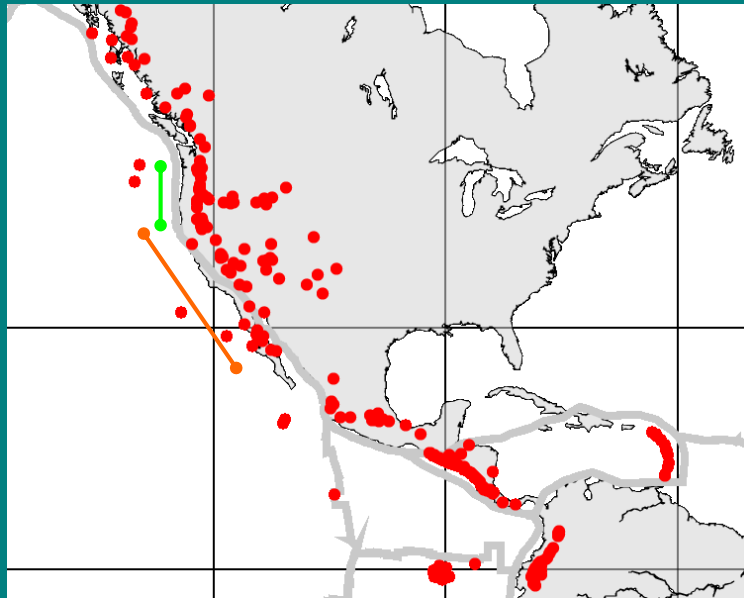


Looking at this map, your students should observe that Divergent plate boundaries are only sporadically associated with volcanoes. Along the Mid Atlantic Ridge, shown in the slide, then only volcanism appears in Iceland (marked with the arrow near the top of the slide) and the Canary Islands (marked with the arrow in the lower part of the slide).

This is due to the type of dataset the Smithsonian Institution has assembled. They have chosen to show only volcanic features that can be observed on land surfaces. This means that this map only shows a dot where a volcano has grown to produce an island or has erupted on a continent. We now know that by far most of the volcanism on Earth actually happens under the ocean along mid-ocean ridges, but these volcanoes are typically not observed, are underwater, and don't make it to the Smithsonian list. I discuss this with students as a great example that when doing real science, the perfect dataset for answering your question usually does not exist. The data are usually lacking in some way; they may be incomplete, they may contain errors, they may even be misleading. Real science happens in spite of that, because the human brain is able to recognize patterns in less than perfect data!

Discovering Plate Boundaries

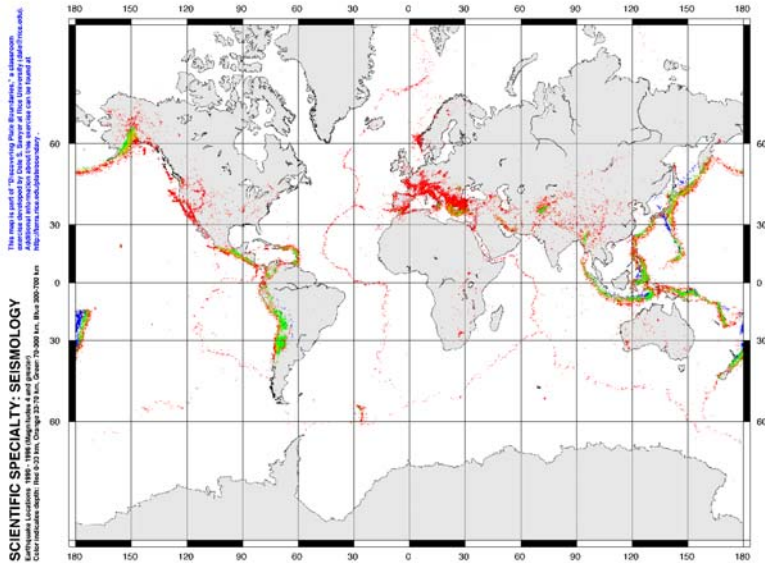
Teachers Guide 2: A Tour of the Maps



Transform plate boundaries, like the plate boundary along the coast of California, may be associated with a broad zone of volcanic activity or may have none. The part of this plate boundary next to the orange bar is a transform plate boundary. The part of this plate boundary next to the green bar is a convergent (subducting) plate boundary. Note that the line of volcanoes becomes tighter where subduction is occurring. This is the Cascade Range in Oregon and Washington, made of of well known volcanoes such as Mt. Ranier and Mt. St. Helens.

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This is a small version of the map for the scientific specialty of “Seismology.” Each dot on this map represents the “epicenter” of an earthquake. The epicenter of an earthquake is the surface location directly over the “hypocenter” of the earthquake. The hypocenter is the location of the break in the rocks, whose relative movement caused the earthquake.

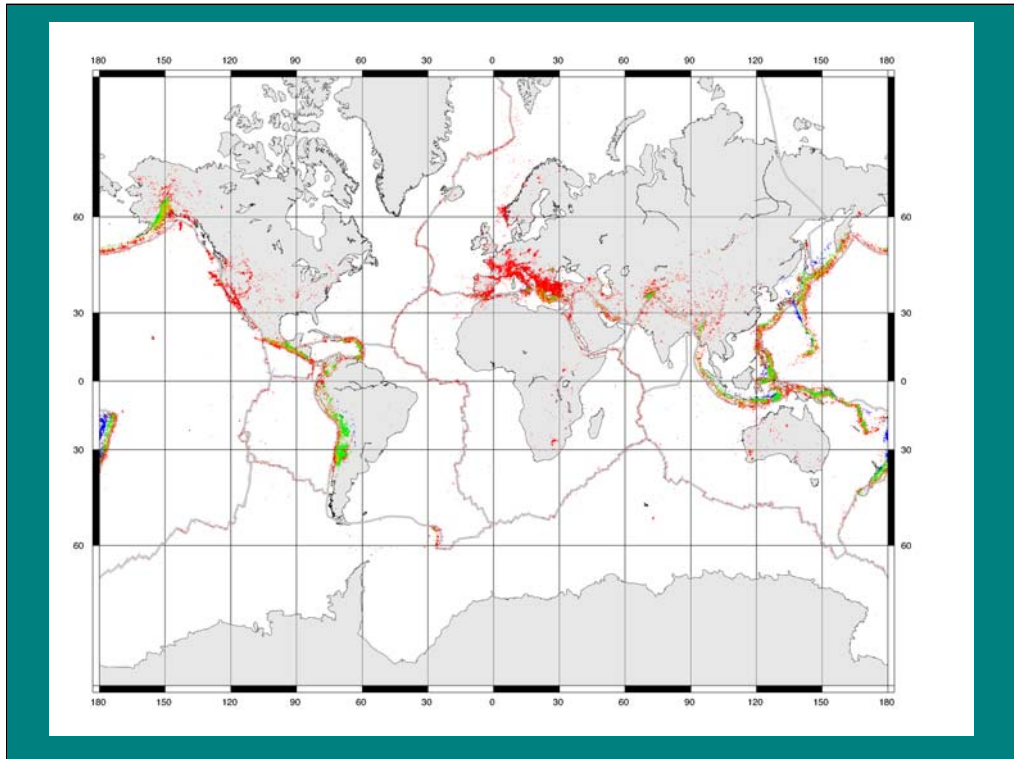
The color of the dots represents the depth of the hypocenter of the earthquake. Red dots are earthquakes between 0 and 33 km depth. Yellow dots are earthquakes between 33 and 70 km depth. Green dots are earthquakes between 70 and 300 km depth. Blue dots are earthquakes between 300 and 700 km depth. Note that in many places, dense patterns of dots may cover other colors of dots. The red dots are plotted first, followed by yellow, green, and then blue.

You may be surprised that we have not shown earthquake magnitude on this map. While there is some association with the size of the largest earthquakes and plate boundary types, the depth distribution is actually much more informative.

These data were obtained from Incorporated Research Institutions for Seismology (IRIS). They include earthquakes that occurred between 1990 and 1996. Any recent 6 year period could be used to construct a similar map. This interval was chosen in 1997 when I created “Discovering Plate Boundaries.”

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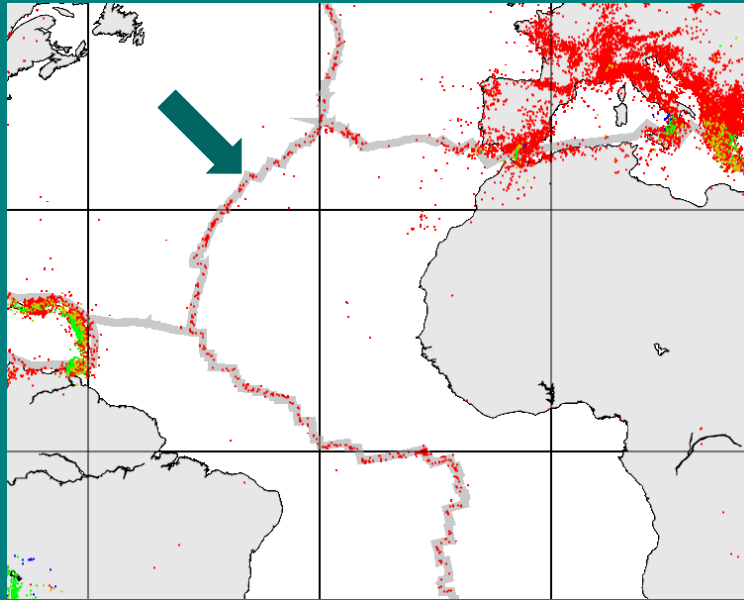


This is the same earthquake location and depth map with the plate boundaries added in gray. I use closeups of this map in the detailed descriptions which follow.

You may want to use this slide in presentations to your class.

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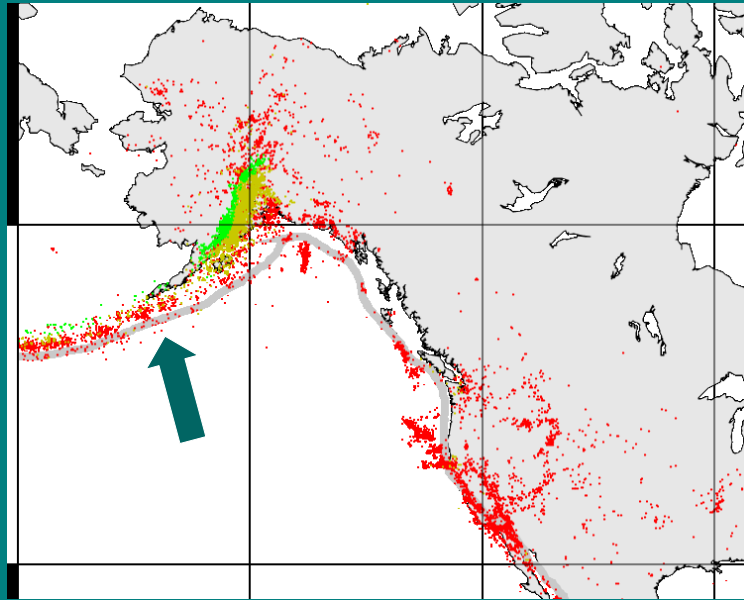


Divergent plate boundaries show up very clearly in the earthquake data. The arrow points to the Mid-Atlantic Ridge. The earthquakes along mid-ocean ridges are dominantly shallow, less than 33 km and shown as red dots. They occur on the plate boundary, not offset to one side or the other. You cannot really tell from these maps, but the earthquake activity is generally confined to a boundary region about 10 km wide. They occur on both the plate boundary segments that are perpendicular to the spreading direction and the segments that are parallel to the spreading direction. The spreading direction here is roughly east - west. The roughly north/south segments of the plate boundary are actually the “spreading center” segments and are divergent plate boundary segments. The roughly east-west segments of the plate boundary are the “transform fault” segments and are transform plate boundary segments.

The earthquakes along mid-ocean ridges are generally small, with Richter magnitudes less than about 6.0.

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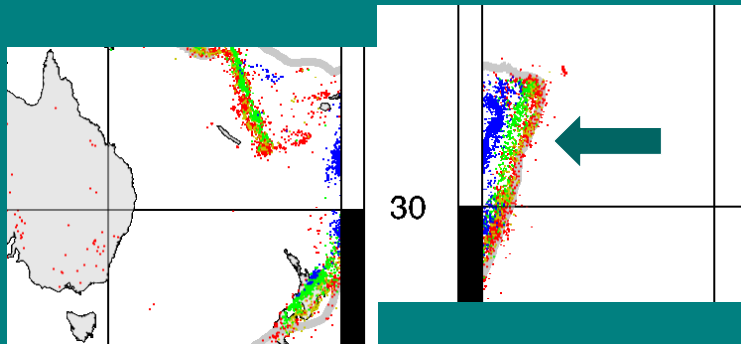
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Convergent (subducting) plate boundaries are also seen quite easily in the earthquake map. Subducting plate boundaries are characterized by shallow earthquakes occurring on both sides of the plate boundary and intermediate and deep earthquakes occurring on one side of the boundary. The deeper quakes occur on the over-riding plate side of the boundary. The quakes of different depths tend to form bands at increasing depth at increasing distances from the plate boundary. You can see this pattern in the Aleutian Island Arc part of the plate boundary between the Pacific plate and the North American plate. The deepest quakes on this margin are shown in green, telling us that they lie between 70 and 300 km depth. Shortly, we will see subducting plate boundaries that include even deeper earthquakes. Note that in this area, the red band straddles the plate boundary, the yellow band is displaced to the north, and the green band is displaced farther north. These earthquakes form the Wadati-Beniof zone and lie near the boundary between the top of the down-going plate and the over-riding plate.

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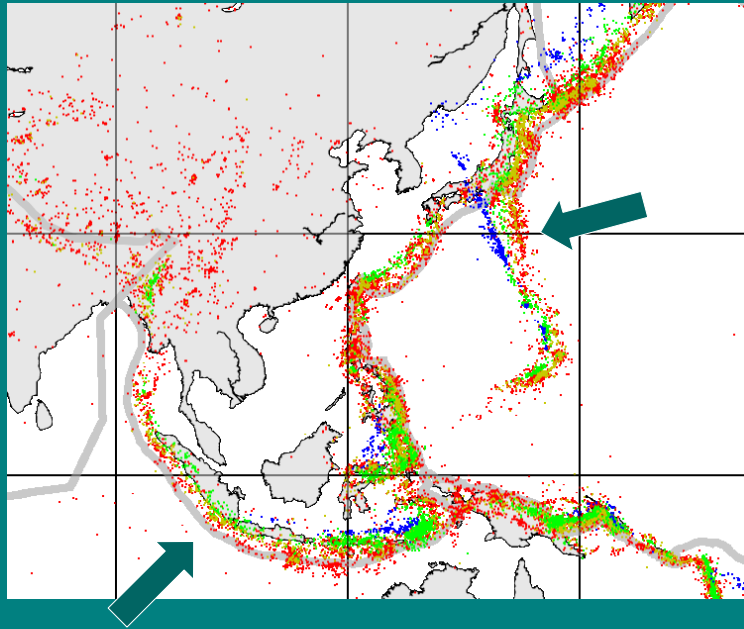
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The deepest Wadati-Beniof zone is associated with the Tonga Trench seen in this slide. It is cut by the map boundary, and thus takes a bit more effort to put it together. As in the Aleutian example, the red band of earthquakes straddles/covers the plate boundary. The yellow, green, and blue bands follow sequentially to the west. Here the Australian plate is over-riding the Pacific plate. The colored bands are closely spaced in this example because the Pacific plate is plunging steeply under the Australian plate. Where the subducting plate is going down at a less steep angle, the bands are more spaced out.

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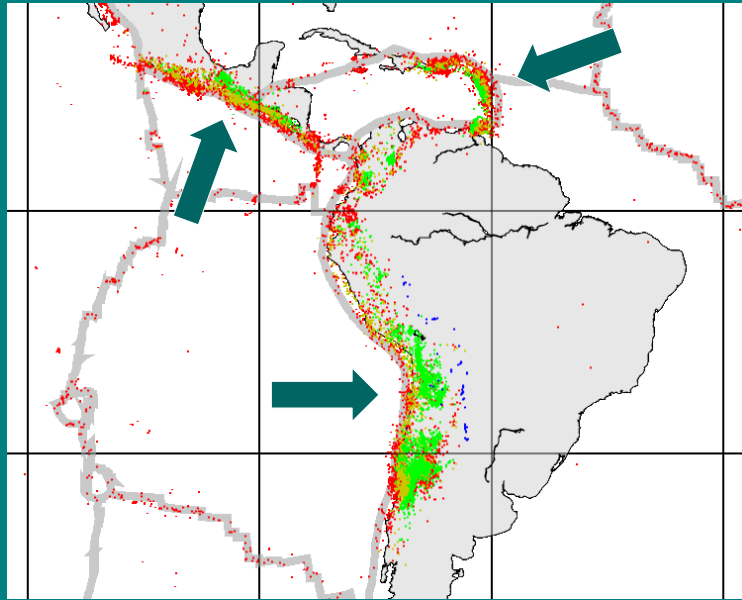
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The Western Pacific Ocean has a number of convergent (subducting) plate boundaries that stand-out in the earthquake map. Note the variations in the depth of the deepest earthquakes in the different subduction systems. All include green band depths (up to 300 km), but only some include blue bands representing quakes deeper than 300 km. Note also that the spacing of the bands varies, showing different angles of descent for the downgoing plates. The arcuate shape of these plate boundaries also shows up very clearly.

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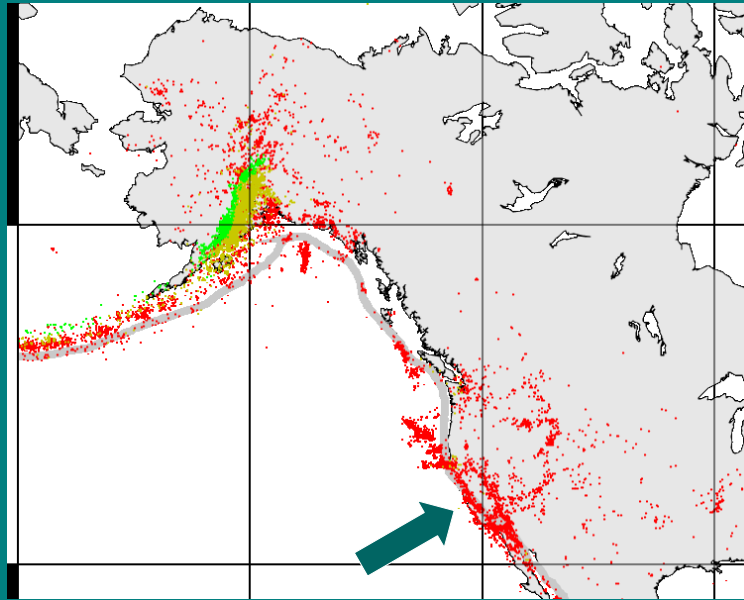
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This slide shows one more example of a subducting plate boundary involving two oceanic crust plates, and two examples of oceanic crust of the down-going plate being subducted under continental crust on the over-riding plate. I am confident that you can pick out which is which! Note that the earthquake depth pattern we associate with subduction is still present. The colored bands for earthquakes under South America are widely spaced. This is an example of a very shallowly dipping subducting plate. It is shallow here because the oceanic crust of this part of the Pacific plate is very young and therefore relatively buoyant. The subduction zone under Central America is much steeper, but does not penetrate as deeply as the South American subduction system.

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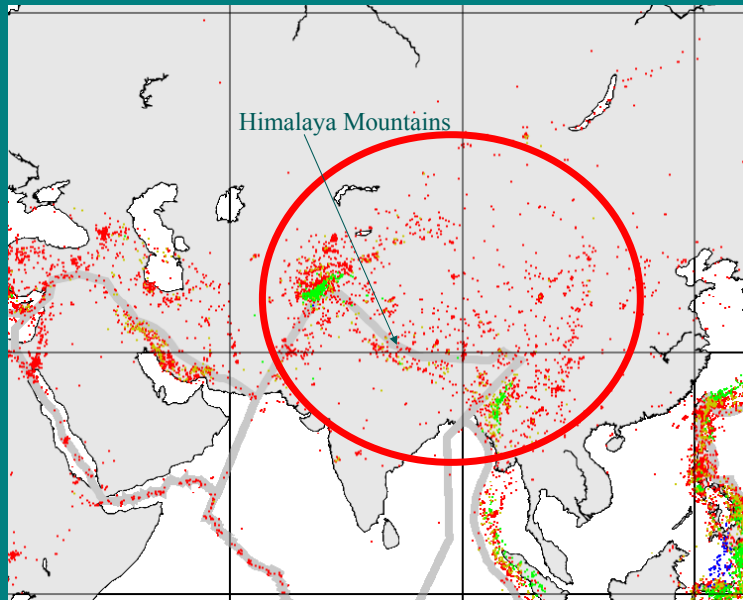
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Transform plate boundaries are typically the site of many shallow earthquakes along a sometimes diffuse zone. The plate boundary between the Pacific plate and the North American plate in California is a good example. Although sometimes very damaging because of big cities in this area, the largest earthquakes on transform boundaries are usually not as large as the largest subduction zone earthquakes.

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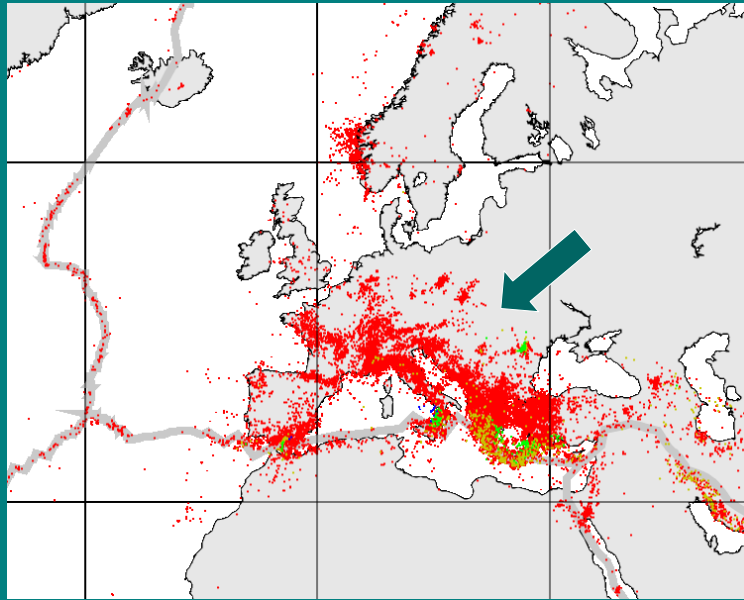
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Convergent (continental collision) plate boundaries are usually marked by very diffuse zones of earthquakes that are mostly shallow, but sometimes intermediate in depth. The Indian plate is colliding with the Eurasian plate, forming the Himalayan Mountains. The effects of this collision are also felt as earthquakes in much of China.

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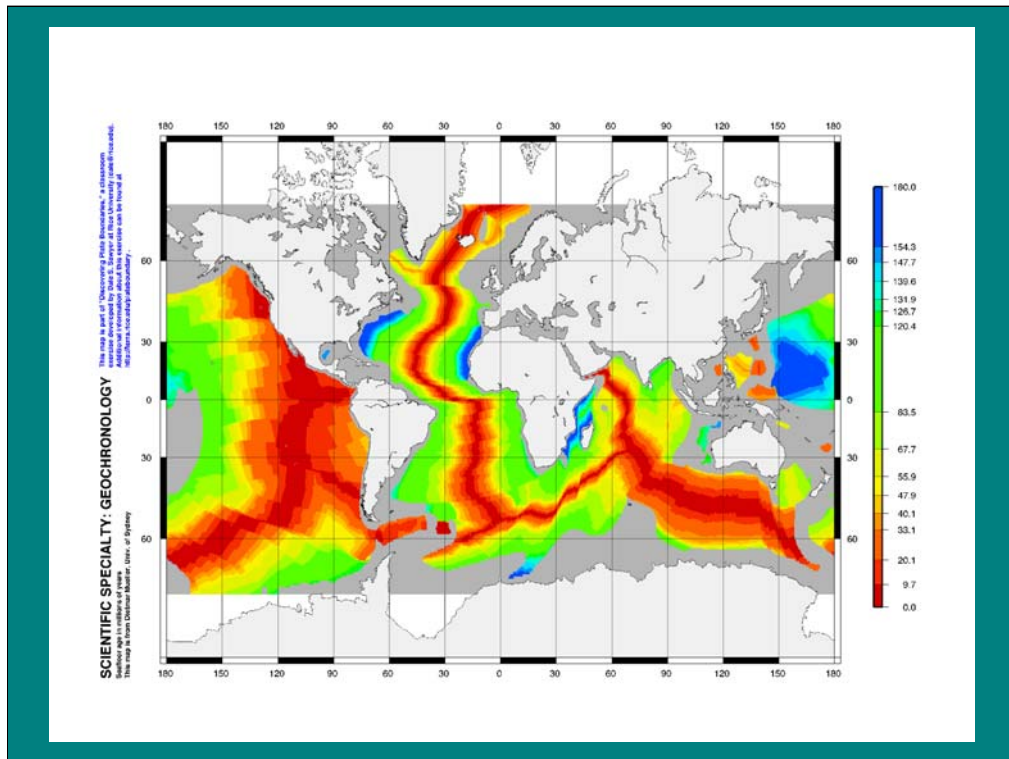
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Earthquake activity is particularly concentrated in the Mediterranean area in this map. The area is characterized by a complicated pattern of small tectonic plates that are continually rubbing against one another. This produces the many bands of earthquakes that you can see on the map. The quakes are almost all shallow. The main east-west diffuse band of earthquakes is related to a general convergence between the African plate and the Eurasian plate. The seismicity appears denser in this area than any other (except perhaps California) because there are many seismograph stations nearby. This means the earthquake catalog includes many earthquakes smaller than would be observed in other parts of the world. This is a good example to discuss with your students. Datasets often have uneven coverage, and it is important that the scientist be aware of this when interpreting their data!

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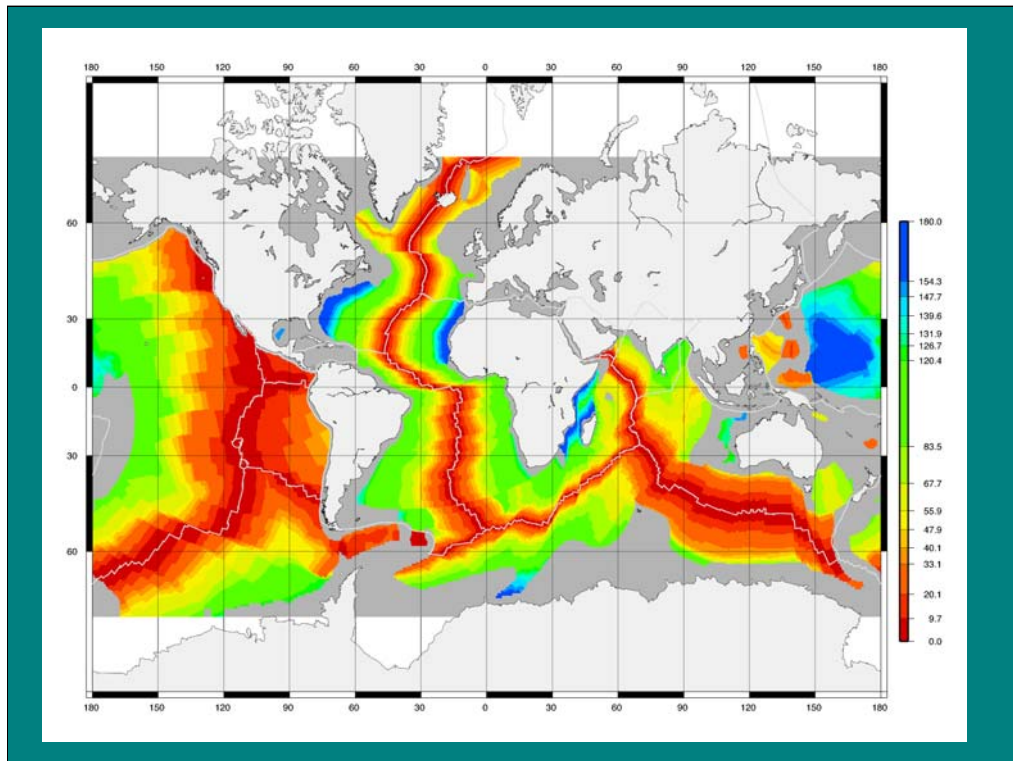
This is a small version of the map for the scientific specialty of “Geochronology.” The colors represent the age of the oceanic crust. There is a color bar on the right side of the map that shows the ages in millions of years. At the bottom of the scale, red represents very young oceanic crust, formed less than 9.7 million years ago. The oldest oceanic crust is represented in blue, and is between 154 and 180 million years old. Data are only shown for areas of the plates that consist of oceanic crust and for which the age is well determined. No data are shown for the land areas because they are underlain by continental crust. No data are shown for some continental margin areas because the sediment cover is great and it is not currently possible to determine the age of oceanic crust there. No data are shown in some high latitude areas because there are not yet sufficient data coverage to reliably determine ages there.

Note that all oceanic crust on Earth is younger than about 180 million years. This is actually surprising given that the Earth was formed about 4,600 million years ago and there are areas of the continents where the rocks are known to be almost 4,000 million years old. The oceans are young because old ocean crust becomes quite dense and tends to be subducted back into the mantle. Thus it does not hang around on the surface of the Earth very long. Continental crust is relatively quite light, both when it is young and when it is old, so it tends to stay at the surface nearly forever.

These data were obtained from Dietmar Muller, a scientist at the University of Sydney in Australia.

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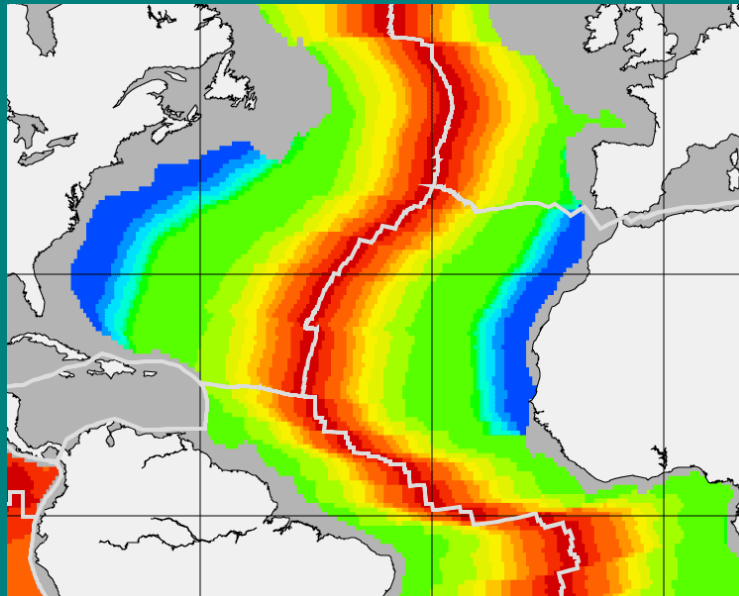


As you have seen before, this is a version of the map with plate boundaries superimposed in gray, and I will be referring to close-ups of this map.

You may want to use this slide in presentations to your class.

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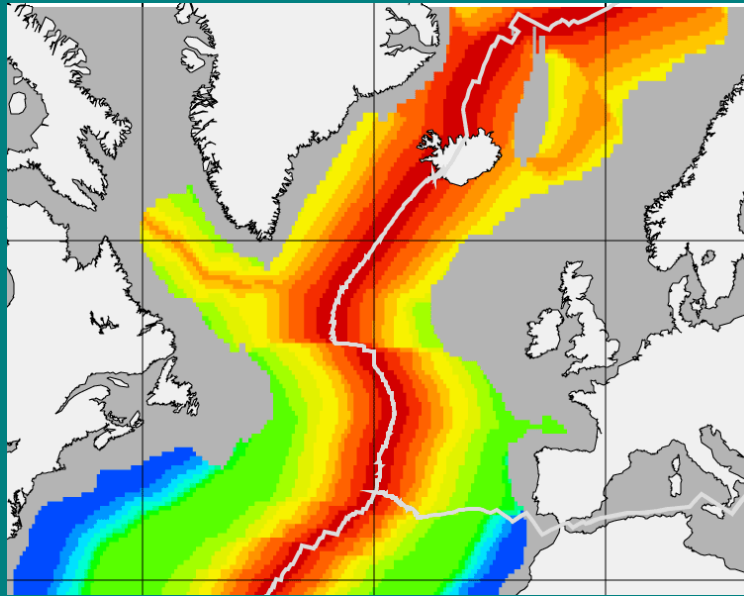


Mid Ocean Ridges, the main type of Divergent plate boundary, practically jump off the map at you! At an active mid-ocean ridge, new oceanic crust is being generated, so the plate boundary should always lie along a band of red on the map. The newly generated crust is formed at the ridge and then moves symmetrically away from the ridge in both directions. Thus the crust becomes older as you move away from a mid-ocean ridge. This pattern is easily seen for the Mid Atlantic ridge in the slide.

The oldest oceanic crust in the Atlantic Ocean is found on the margins of North America and Africa. The blue crust there was formed when Africa had just started to spread away from North America.

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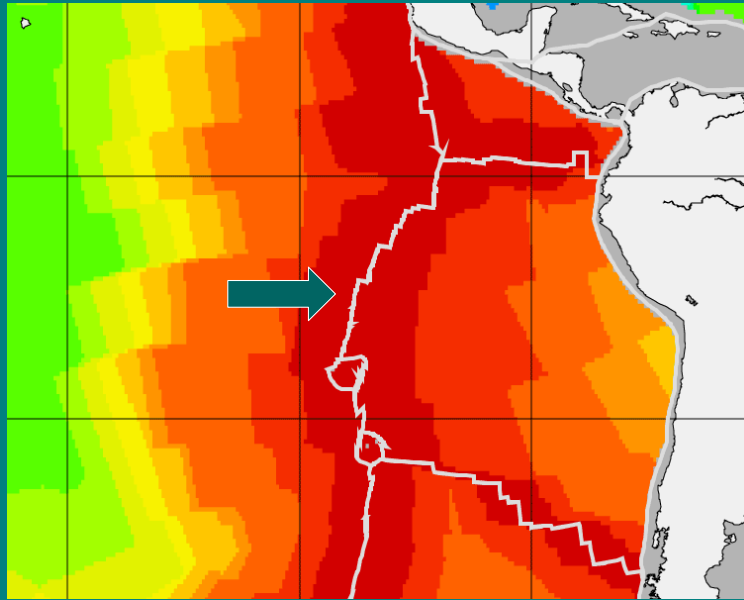
This is the Mid-Atlantic Ridge in the far North Atlantic Ocean. The divergent plate boundary goes right through Iceland. There you can observe volcanism and seafloor spreading happening at the surface.

Before going forward to the next slide, please notice how wide the red, orange, and yellow bands are in this image. This is an example of a “slow-spreading” ridge. New crust is created at this ridge at a rate of about 4 cm per year. In the next figure we will look at a ridge spreading about 3 times as fast! Do you expect the red, orange, and yellow bands to be wider or narrower in that image?

While you are thinking, I would also like to point out a mid-ocean ridge that was active in the past but is not active now. It is in the Labrador Sea, between Canada and Greenland. It has a seafloor age pattern like that of an active ridge except that the band in the middle is not red. That means it stopped spreading at “orange time.” That was between 33.1 and 40.1 million years ago (check 2 slides back for the legend which gives the ages of each color band). That is why there is no plate boundary between Canada and Greenland. They are both part of the North American plate now.

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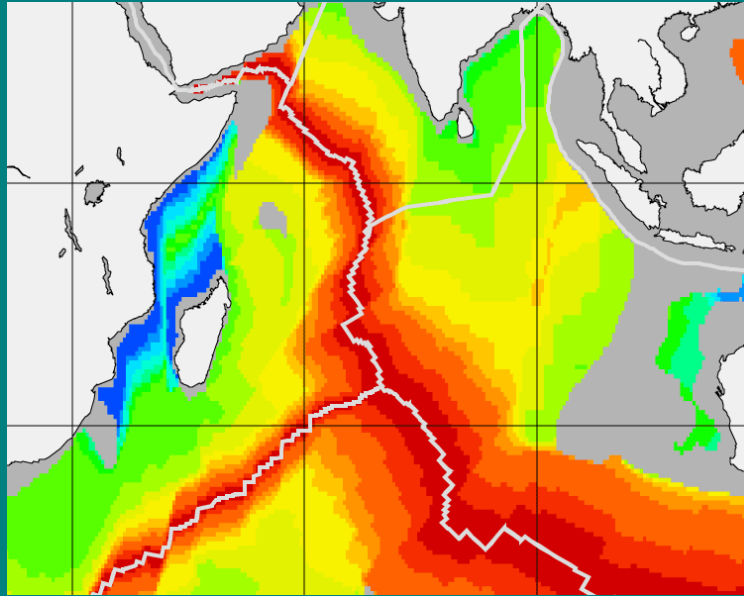


The arrow points to the East Pacific Rise. It is also a divergent plate boundary. It is displayed at the same scale as the last slide. Are the red, orange, and yellow bands on either side of the spreading center wider? They sure are! This is the fastest spreading rate ridge; it is creating about 12 cm of new oceanic crust on each side of the ridge each year. That is about as fast as your hair grows; fast huh?

There are two spreading center ridges that branch from the East Pacific Rise and go to the east. They are spreading more slowly. The two small enclosed circles in the lower middle of the slide are microplates. They are bordered by divergent and transform plate boundaries on all sides.

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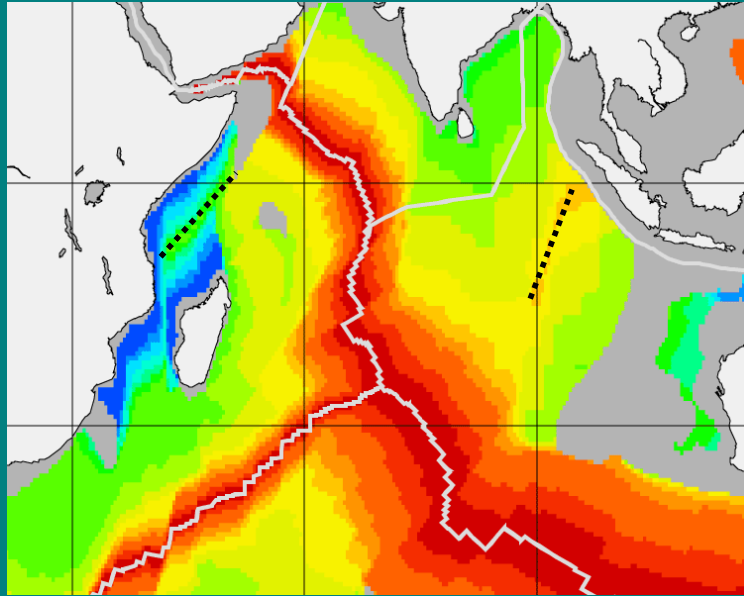


This is the Indian Ocean. It has a network of divergent plate boundaries. Note the variations in spreading rate. Also note that fast spreading ridges have fewer but larger transform offsets than slow spreading ridges. Here the contrast is greatest between the ridge in the lower right and the lower left of the slide.

Now, a puzzler for you! Can you find two extinct spreading centers in this slide? Can you tell which of the two became extinct first?

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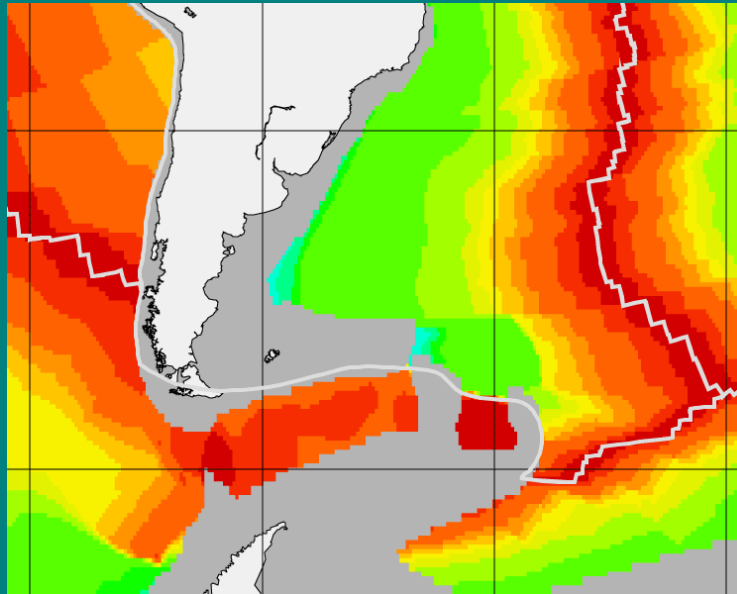
Teachers Guide 2: A Tour of the Maps



The two black dotted lines show extinct spreading centers. The extinct spreading center in the upper left, stopped spreading long ago (in green time). The spreading center in the upper right stopped spreading in yellow to orange time, much more recently. We can use the colorbar from the map to attach numerical ages to the time during which these spreading centers were active. This is not actually part of the exercise, but it is an example of the amazing amount of information contained in these data!

Discovering Plate Boundaries

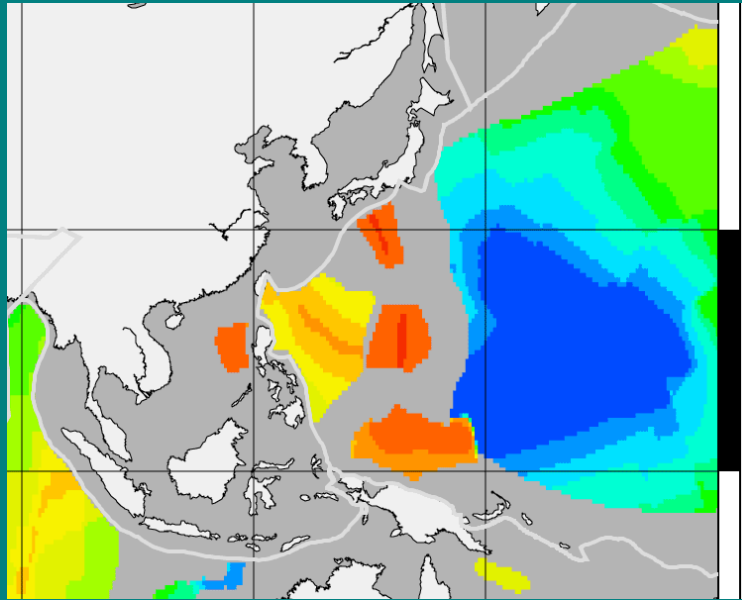
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Convergent (subducting) plate boundaries have no consistent seafloor age along the boundary. We see here that along the subducting boundary on the west side of South America, the age of the oceanic crust being subducted varies from pale orange to red age. This is because oceanic crust of any age can be subducted. This is a subduction system with continental crust in the over-riding plate. Because it is continental there are no seafloor age data. Frequently the students will describe such boundary as one between data and no data. For older students I usually push on them to think about that a bit deeper and describe the boundary in terms of the age of what is being subducted rather than just the presence or absence of data.

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps



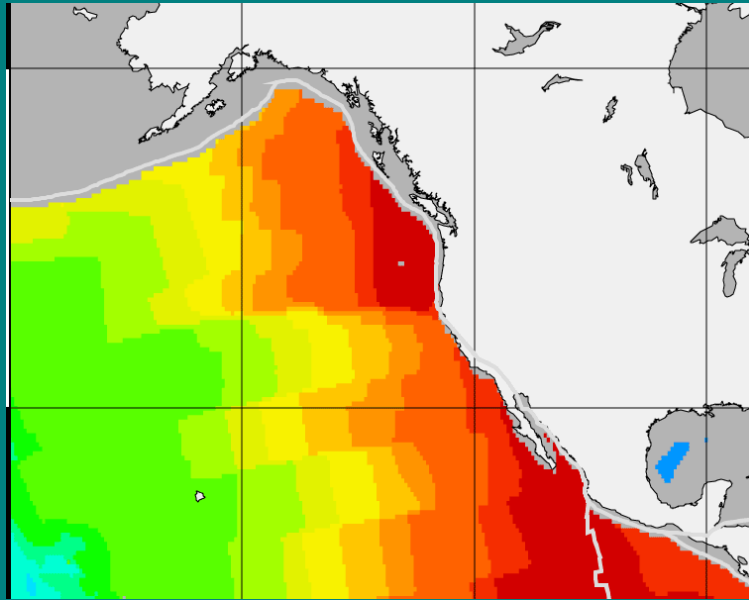
The Western Pacific is complicated. The students should note that in the few places where there are data near the subducting boundaries, the age of the oceanic crust is varying. Putting this whole story together will likely only come in the second phase of the exercise when the students put different kinds of data together for this area.

As a side note, the oldest oceanic crust known is in the blue area of this slide. Because it is so close to the subduction boundaries of the western Pacific, we know that it won't be but a few million years before it is subducted and recycled into the mantle.

Do you see any extinct spreading centers here? There is one in the lower left that stopped spreading at orange time and one in the center that stopped spreading later in orange time!

Discovering Plate Boundaries

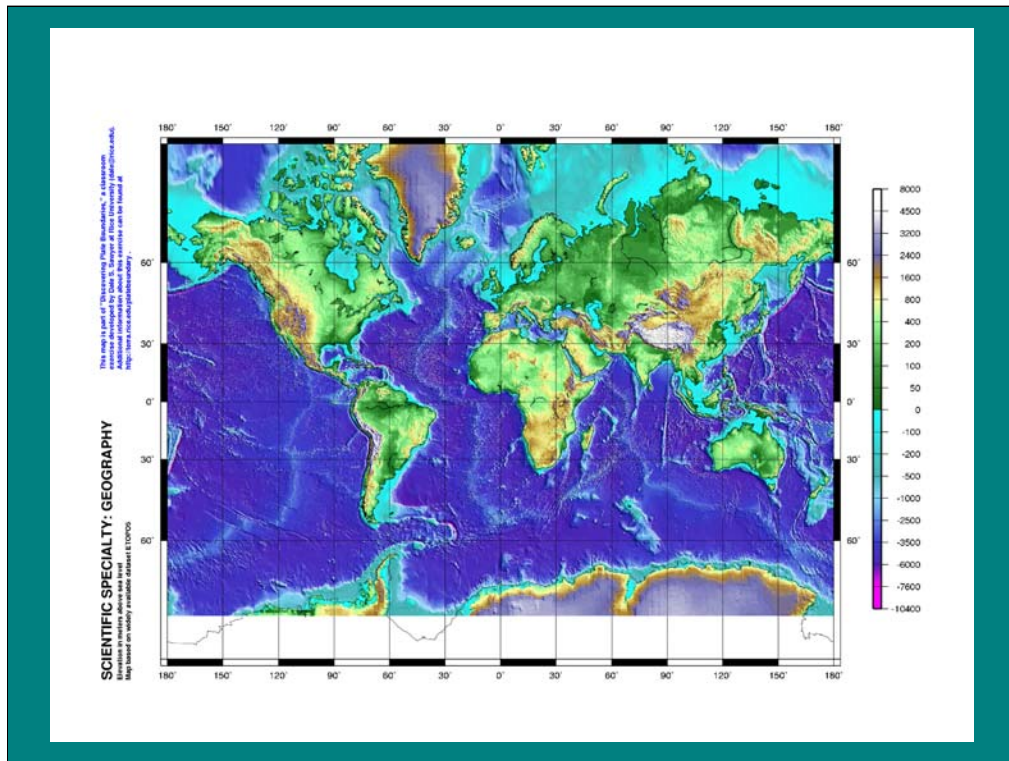
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Here we see the age pattern in oceanic crust off the subduction boundary of the Aleutians and the transform boundary along the California coast. Transform plate boundaries are like subduction boundaries in that the age can vary along the boundary.

Discovering Plate Boundaries

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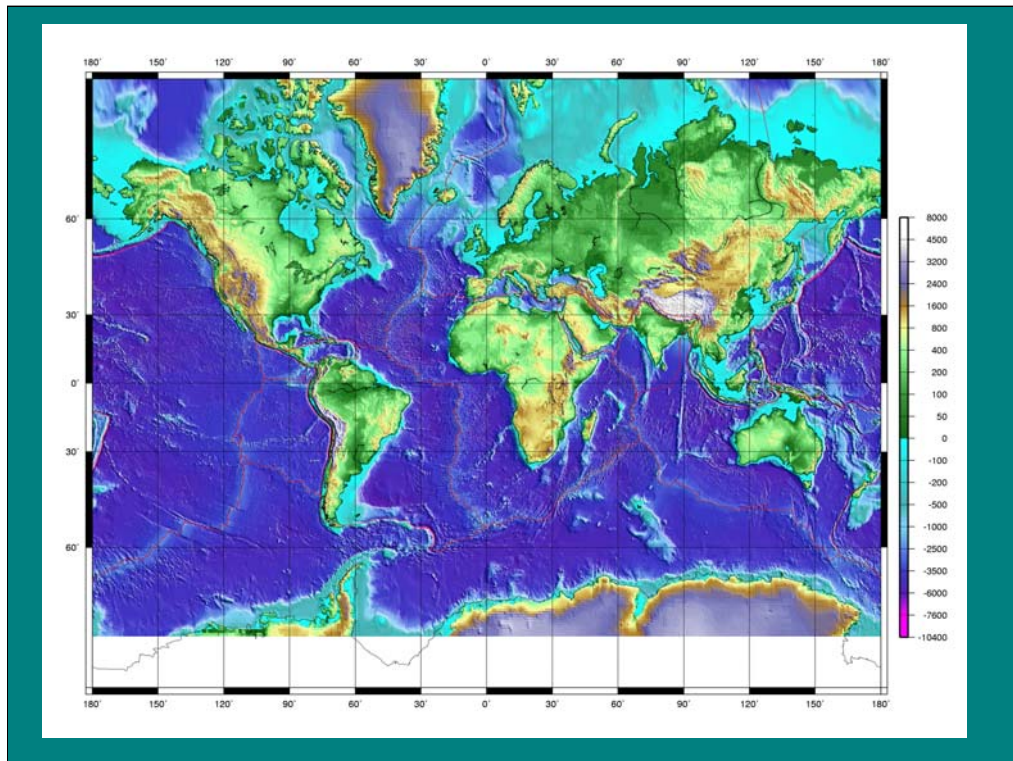


This is a small version of the map for the scientific specialty of “Geography.” The colors represent the elevation of the land surface and of the bottom of the ocean. Elevation is expressed in the color bar in meters. The pale blue through dark blue and then purple colors are shallow to deep ocean areas. The dark green through brown, gray, and white are low to high land elevations.

These data were obtained from the US National Geophysical Data Center and are called the “ETOPO5” dataset. ETOPO5 stands for Earth Topography at 5 minute spacing.

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps

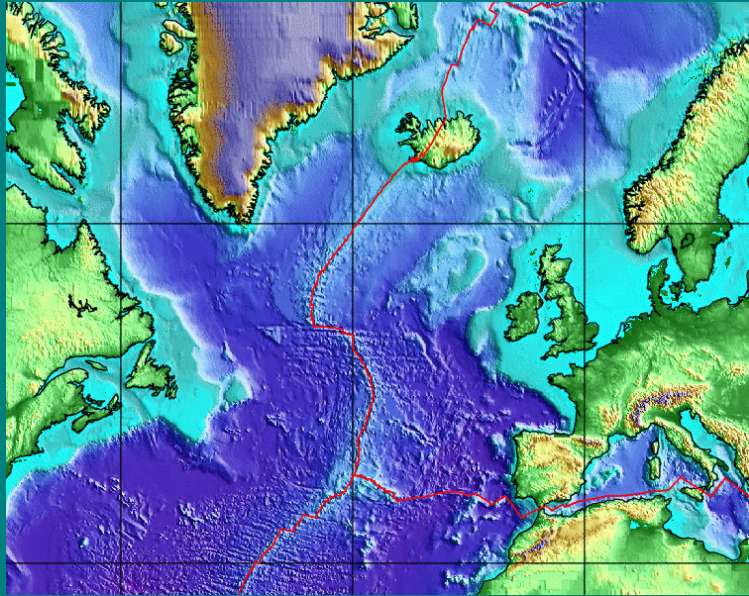


This is a version of the map with plate boundaries superimposed as narrow red lines, and I will be referring to close-ups of this map.

You may want to use this slide in presentations to your class.

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps

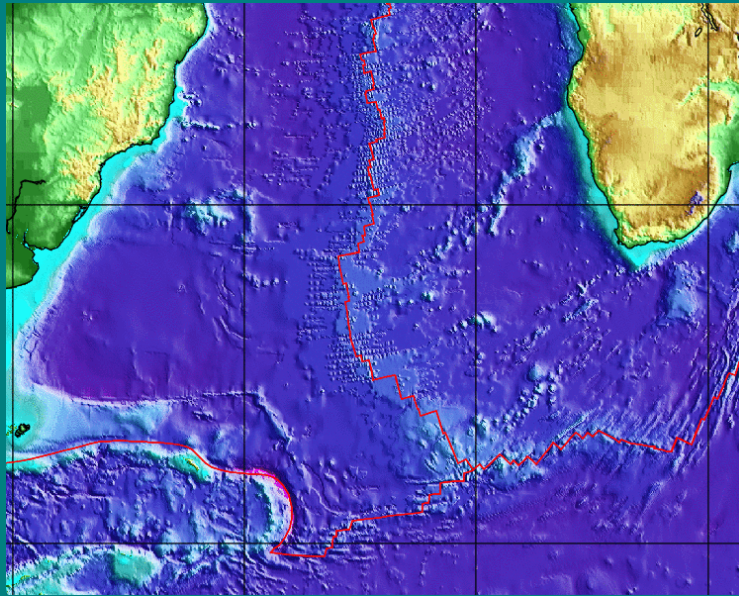


We will start with the topographic signature of divergent plate boundaries. The first observation is that the divergent boundary follows the peak of a seafloor mountain range. The water depth is greater on each side of the plate boundary. The depth change is usually roughly symmetric. The average depth of mid-ocean ridge crests is 2500 meters. The ridge crest is unusually shallow near Iceland, where the ridge actually emerges from the water. Ridge crests are cut by many crossing features called transform faults or fracture zones. These look like slashes or cuts in the seafloor running perpendicular to the spreading direction. They are the “scar” of the offset in the ridge when that part of the oceanic crust was formed.

Slow spreading ridges like this one have closely spaced fracture zones with small offsets at the ridge crest.

Discovering Plate Boundaries

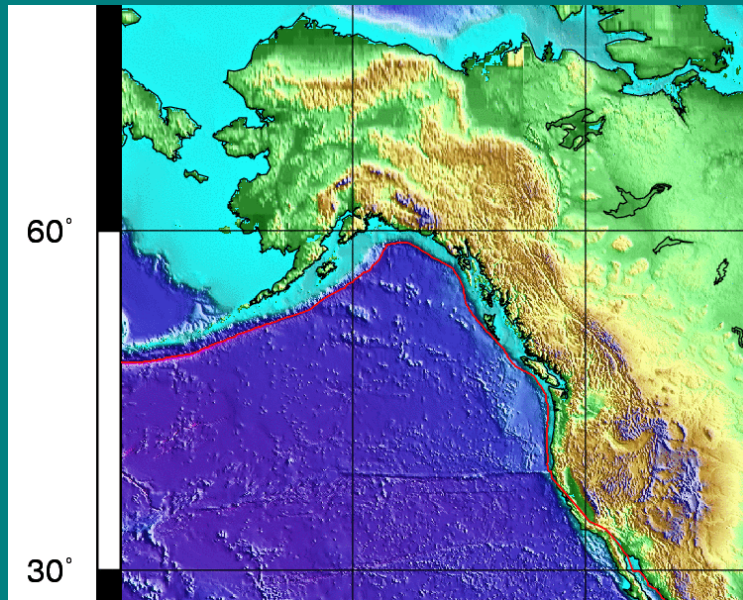
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The Mid-Atlantic Ridge in the South Atlantic looks the same.

Discovering Plate Boundaries

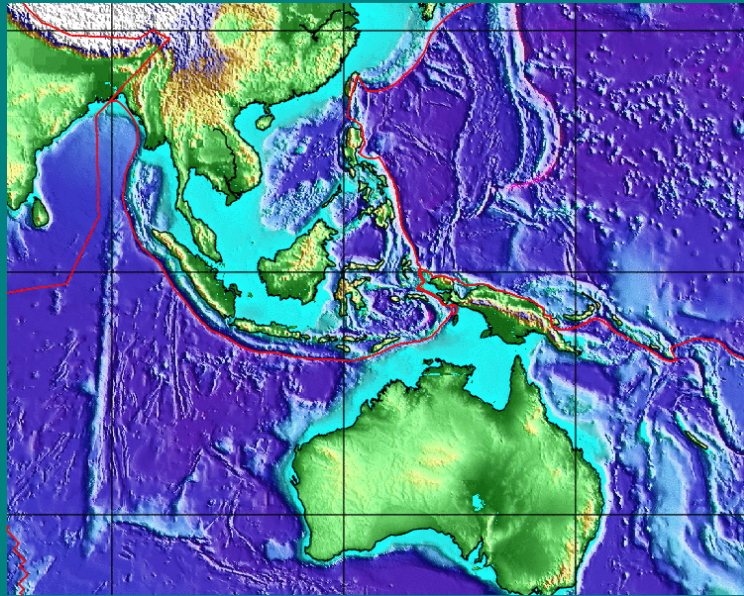
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The topographic pattern for convergent (subducting) plate boundaries is very different. The plate boundary usually corresponds exactly to a deep trench. It is hard to see that in this image because the red line covers the dark blue or purple of the narrow trench. The over-riding plate shows either shallow water or islands in an arcuate shape. The down-going plate is of normal oceanic depth. The deepest parts of the world's oceans are in these types of trenches.

Discovering Plate Boundaries

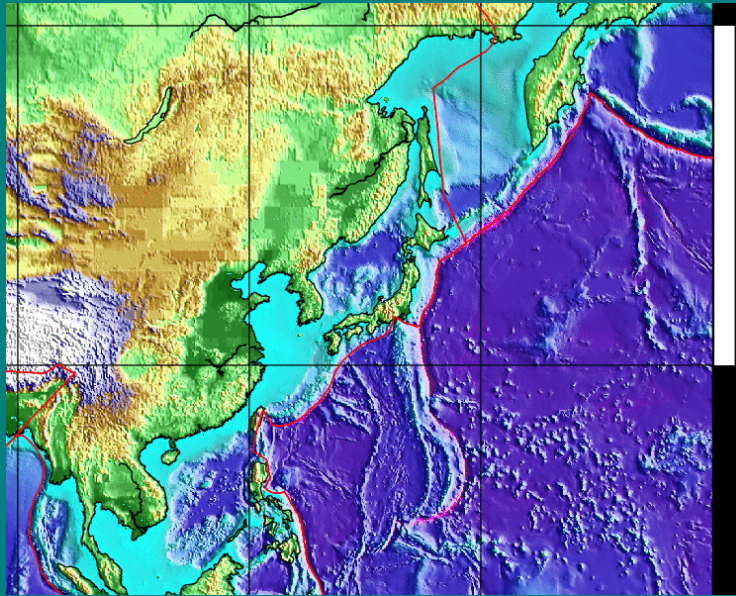
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We see that the association of trenches along plate boundaries and the pattern of shallow water or islands on one side and deep water on the other side occurs repeatedly in the Western Pacific.

Discovering Plate Boundaries

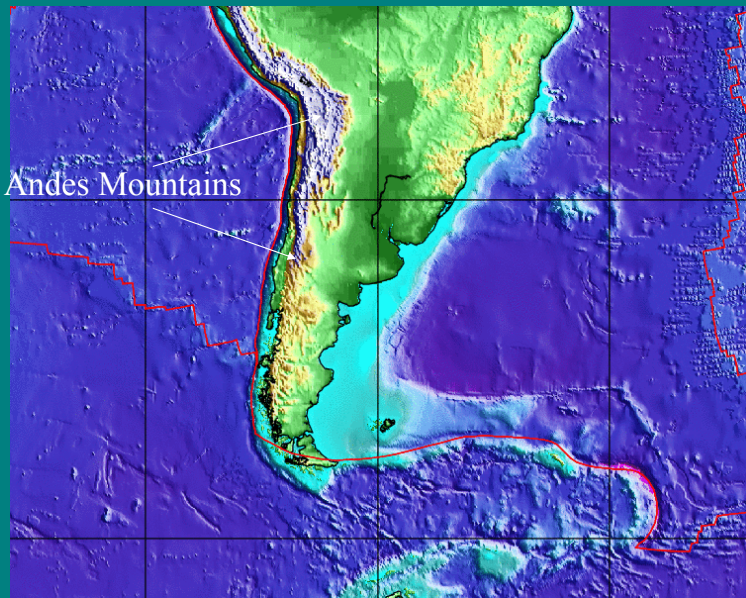
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More of the same!

Discovering Plate Boundaries

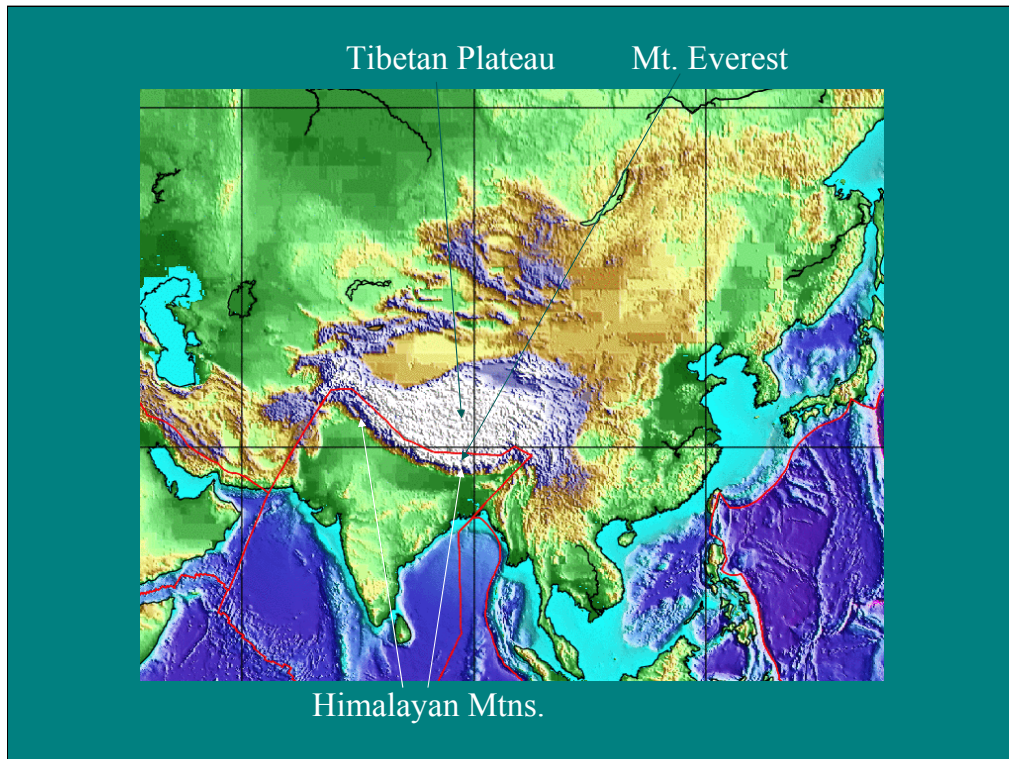
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When oceanic crust is subducted beneath continental crust, the trench is still present. However, the Island Arc is replaced with high Mountains, in this case the Andes Mountains.

Discovering Plate Boundaries

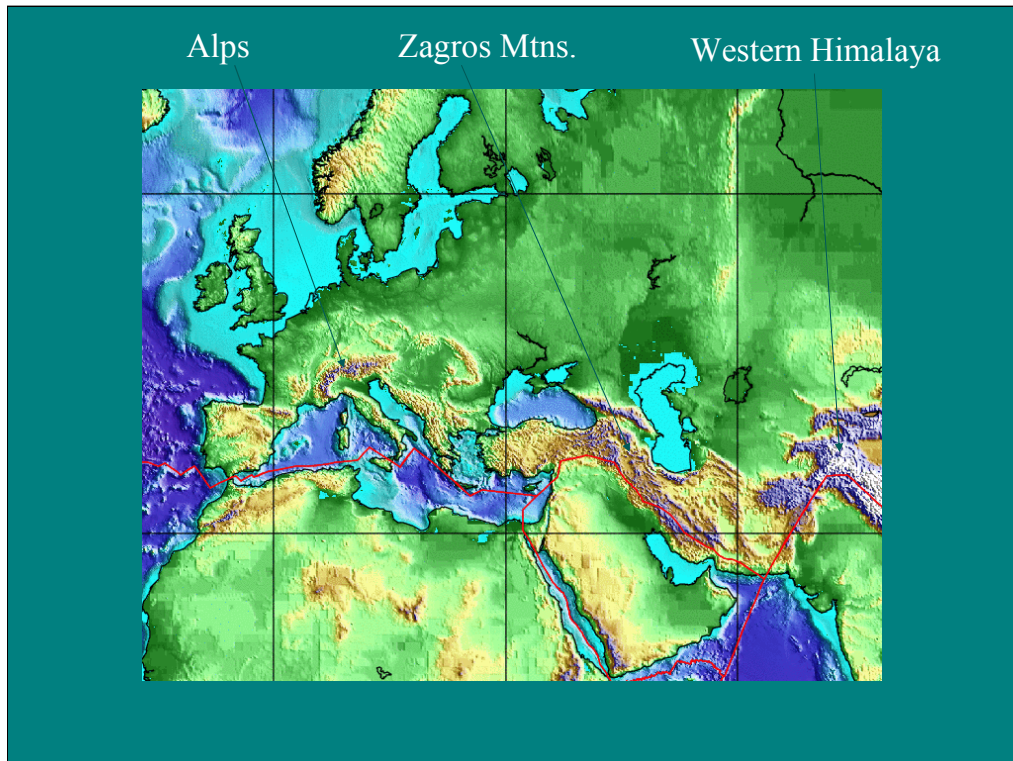
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A convergent (Continental collision) plate boundary is often the site of mountain building. The Himalaya's, which include Mt. Everest, the world's highest point, and many of the other tallest mountains in the world, are the result of continental collision. In this case, the Indian plate is colliding with the Eurasian plate. All of the high topography in the central part of this slide is the result of this collision.

Discovering Plate Boundaries

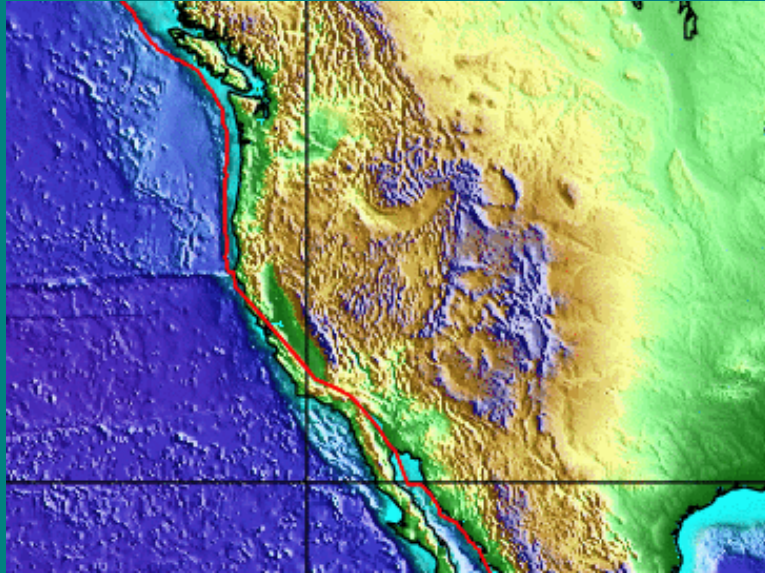
Teachers Guide 2: A Tour of the Maps



The mountain chains that cross this slide horizontally from Spain to Turkey to Iran are also the result of continental collision.

Discovering Plate Boundaries

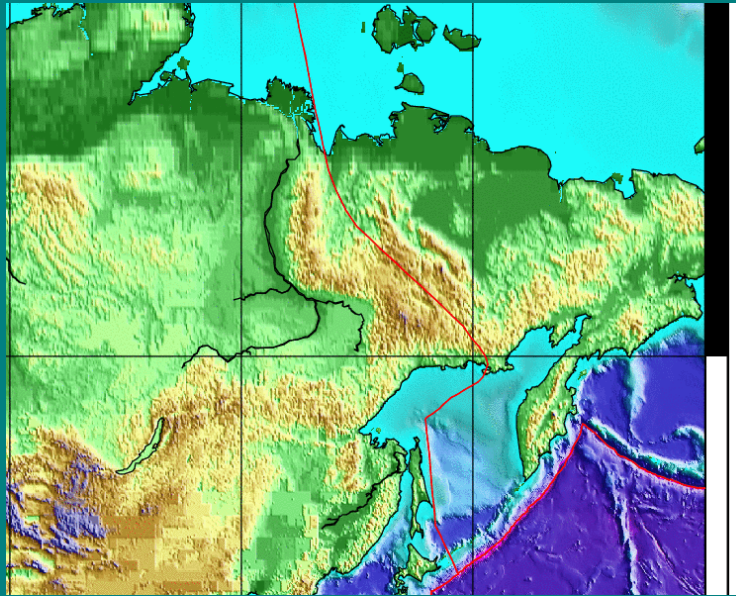
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There is no simple topographic pattern associated with transform plate boundaries. The plate boundary in California is a complex mix of basins (low areas filled with water or sediment) and mountains. Transform boundaries are often recognized by the absence of the characteristic features of either convergent or divergent plate boundaries.

Discovering Plate Boundaries

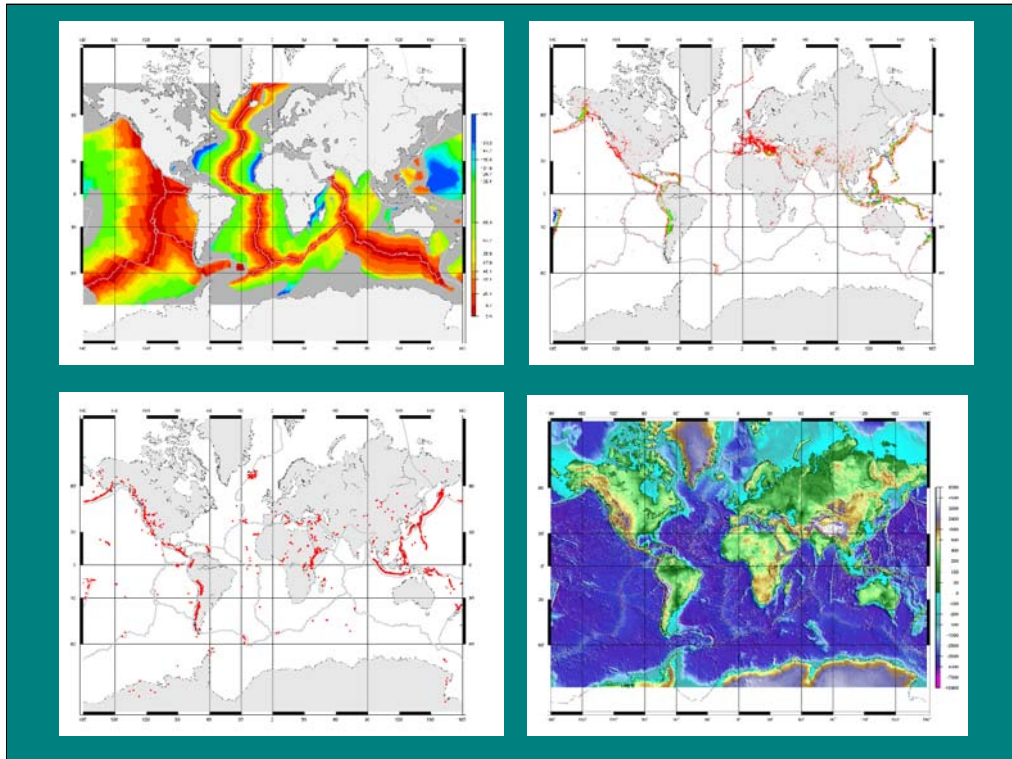
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A plate boundary which students often find enigmatic is this one between the Eurasian and North American plates in Siberia. It runs roughly north south in the top center of the picture. It really only has a signature in topography, lacking earthquakes, volcanoes, or any dated oceanic crust to. It is a transform boundary that is poorly defined by scientists.

Discovering Plate Boundaries

Teachers Guide 2: A Tour of the Maps



I hope that I have been able to convey some of the excitement that I feel in looking at these data maps! They are a rich source of insight into plate tectonic processes.

Although this exercise involves student discovery of plate boundaries, it is most effective if the teacher can interact with the student groups working with the maps. I move around from group to group throughout the exercise, listening to student discussion and asking questions. I point out interesting areas on the maps to spur deeper thinking on the part of the students. The examples I typically use from each map are the ones that I have shown you in this presentation.

Thank you for using this presentation and good luck using the exercise in your own classroom!