Instructor Slide Guide:

These slides have been created to use during synchronous lecture sessions. Instructor Slide Guides have a gray background and provide guidance on how to administer the slides to students. A jigsaw is included within the activities where students will be in “expert” groups to begin and then will be mixed into a “mixed group” later.

Recommended Actions:

- Before class, instructors will set up a Google drive folder for their students to access and create a new Google slide set for each break out room group. Only the first slide (**slide 2** here) will need to be included in the group slides. They will also create a second Google drive folder for a “mixed group” slide set (see slide 8 for details).
- During class, instructors will create break out rooms into 4 groups of 4 students each.
    - In a class of 30: 8 groups of 4-5 students (each expertise will have 2 groups)
    - In a class of 50: 12 groups of 4-5 students (each expertise will have 4 groups)
    - In a class of 100: 24 groups of 4-5 students (each expertise will have 6 groups)
- During class, instructors will open and have access all group’s slides and the master slides.
    - Instructor will add slides to the group’s slides throughout the lecture as directed in the guide.
    - Instructors should monitor group slides during lecture so they can ensure accurate progress is being made.
- Set the first break out room timer at 15 minutes.
- Before sending students in to each break out room, instructor may want to share their screen with student’s slide to briefly explain what students will be doing in the break out room.
- Once students return to the main room, a reporter from each group shall share 3 observations.

Instructor Share Screen:

- Break Out #1 Google slide- ensure all students have access and point out basic functions
- Dynamic Planet map- how to read and make map observations (Legend, North arrow, scale, etc.)

Break Out #1: Ice Breaker

In groups, visit the The Dynamic Planet Map (courtesy of the USGS)

1. What do the different types of triangles represent?
2. What do the different types of circles represent?
3. Develop a list of observations (*What patterns do you see?*)
4. Develop a list of questions (*What are you wondering?*)
5. Elect a representative from your group to report out your top 3 observations.

Type Answers Here!

Instructor Slide Guide:

The following slides (4-7) are the “expert” slides for the first part of the jigsaw. When students go back in to their break out rooms they are to become the expert in their assigned specialty. Each student will need to be able to explain their data and expertise to a student who has never seen the data before.

Recommended Actions:

- As groups are sharing their insights from the previous break out room activity, copy/paste a different “expert slide” (**slides 4-7** here) to each group’s slides for break out #2.
    - Ex. For a class of 30 (8 groups): Group 1- slide 4, Group 2- slide 5, Group 3- slide 6, Group 4- slide 7, Group 5- slide 4, Group 6- slide 5, Group 7- slide 6, Group 8- slide 7
- Remind each student that they will need to share their expertise to students who have never seen it before. They will use collective expertise information to solve a mystery!
- Set the break out room timer at 25 minutes.
- When students return, let them know that they will now be separated into mixed groups where one person from each specialty will be in their group. They are to share their knowledge with each other and use their combined knowledge to answer the next slide’s questions.
- Tip: If the Jules Verne Voyager Website becomes inactive, you can have students view the screenshots on slides 39-42 or view these maps: https://serc.carleton.edu/NAGTWorkshops/urban/activities/22207.html or https://plateboundary.rice.edu/

Instructor Share Screen:

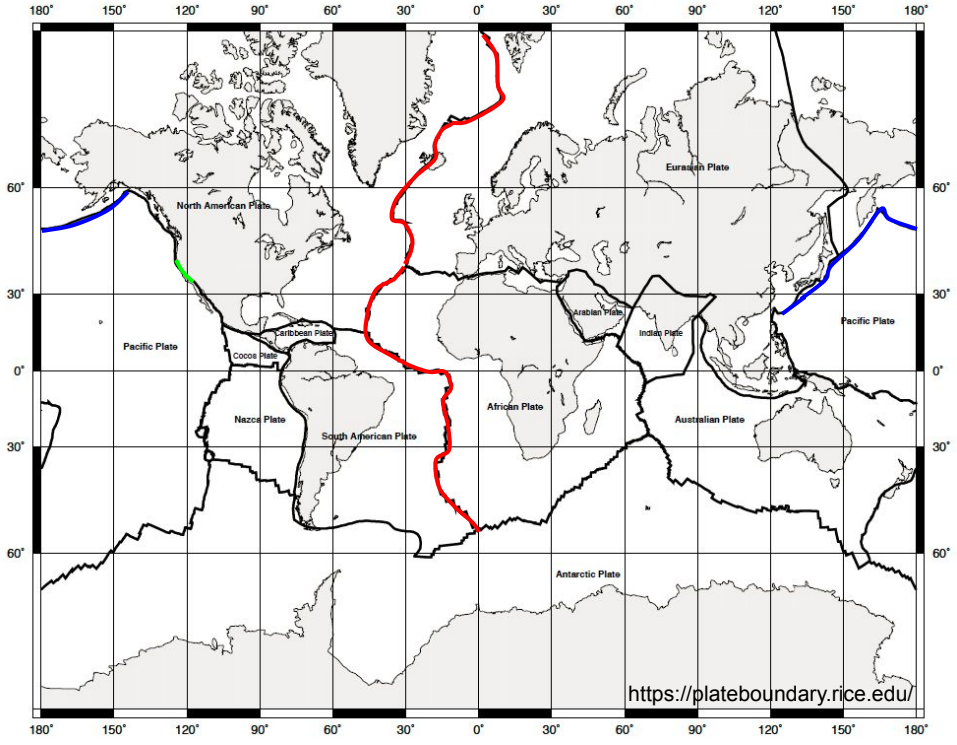
- Break Out #2 Google slide- ensure all students have access and point out basic functions
- Jules Verne Voyager Junior- how to manipulate features/data/legends shown

Break Out #2: Congrats, you've been promoted!

In groups, visit the Jules Verne Voyager, Junior interactive map. Under "add features" select "earthquakes" and then click "make changes"

1. What is your specialty? Hint: not just "earthquakes" but what do we call a scientist who studies this?
2. What is your data showing you? Hint: click "legend on/off" to see what the colors indicate
3. How does your data correspond with the plate boundaries map (below-ignore the colored lines for now): Any similarities? Any differences?
4. How does your data act along the red line on map below? The green line? The blue line?
5. Each person in this group needs to be prepared to explain your data to students who have never seen it before!!

Type Answers Here!

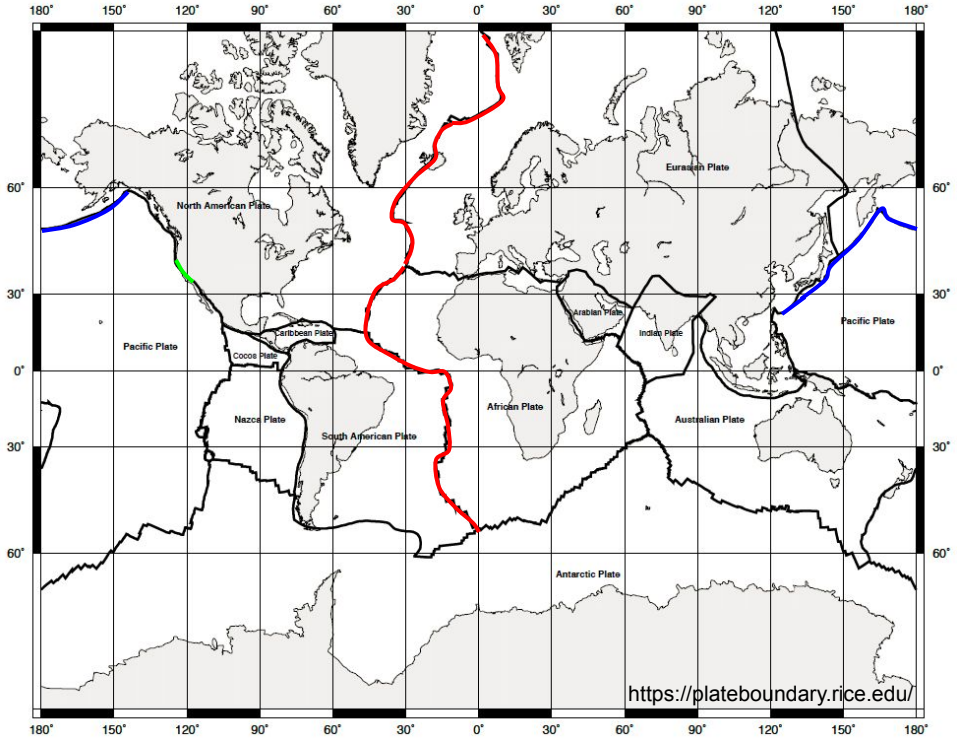


Break Out #2: Congrats, you've been promoted!

In groups, visit the Jules Verne Voyager, Junior interactive map. Under "add features" select "volcanoes" and then click "make changes"

1. What is your specialty? Hint: not just "volcanoes" but what do we call a scientist who studies this?
2. What is your data showing you? Hint: click "legend on/off" to see what the colors indicate
3. How does your data correspond with the plate boundaries map (below-ignore the colored lines for now): Any similarities? Any differences?
4. How does your data act along the red line on map below? The green line? The blue line?
5. Each person in this group needs to be prepared to explain your data to students who have never seen it before!!

Type Answers Here!

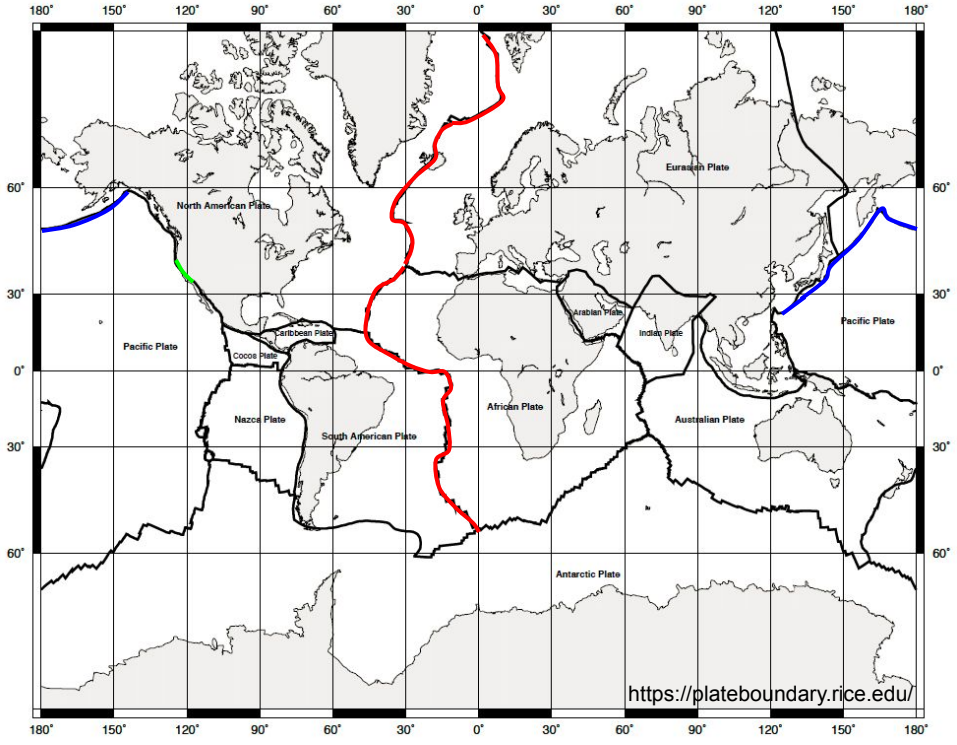


Break Out #2: Congrats, you've been promoted!

In groups, visit the Jules Verne Voyager, Junior interactive map. Under "select a base map" select "color topography" and then click "make changes"

1. What is your specialty? Hint: not just "topography" but what do we call a scientist who studies this?
2. What is your data showing you? Hint: click "legend on/off" to see what the colors indicate
3. How does your data correspond with the plate boundaries map (below-ignore the colored lines for now): Any similarities? Any differences?
4. How does your data act along the red line on map below? The green line? The blue line?
5. Each person in this group needs to be prepared to explain your data to students who have never seen it before!!

Type Answers Here!

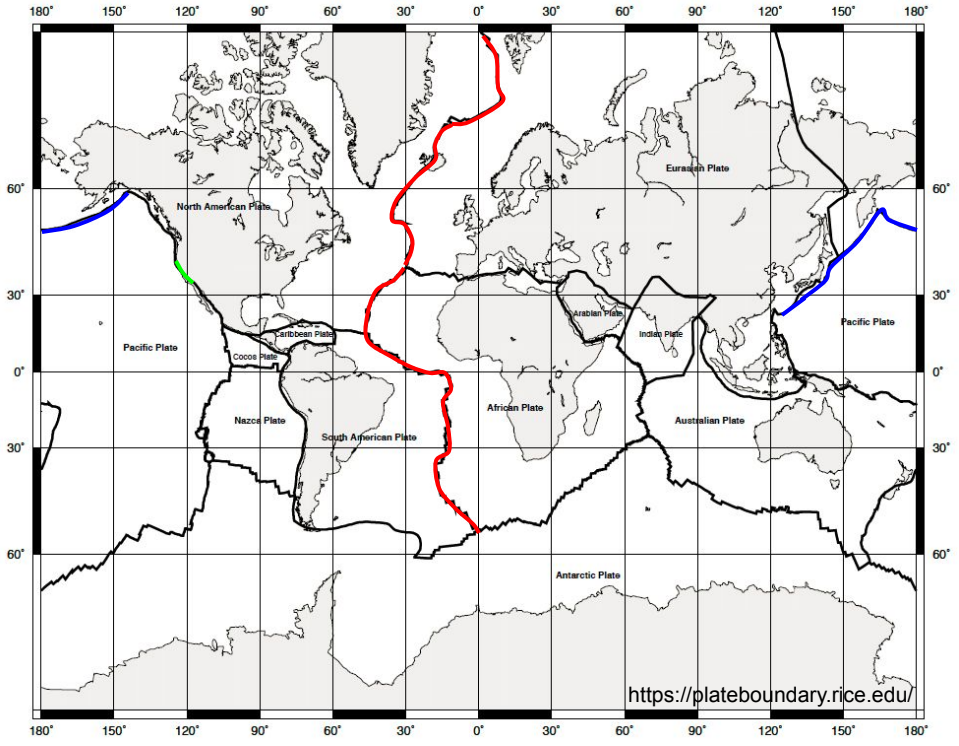


Break Out #2: Congrats, you've been promoted!

In groups, visit the Jules Verne Voyager, Junior interactive map. Under "select a base map" select "ocean floor age" and then click "make changes"

1. What is your specialty? Hint: not just "ocean floor ages" but what do we call a scientist who studies this?
2. What is your data showing you? Hint: click "legend on/off" to see what the colors indicate
3. How does your data correspond with the plate boundaries map (below-ignore the colored lines for now): Any similarities? Any differences?
4. How does your data act along the red line on map below? The green line? The blue line?
5. Each person in this group needs to be prepared to explain your data to students who have never seen it before!!

Type Answers Here!



Instructor Slide Guide:

The following slides (9-20) are the “mixed group” slides. When students go back in to their break out rooms they will take turns sharing their expertise.

Recommended Actions:

- Creating the new break out rooms may take some time (especially with larger classes). When students return, it is recommended to give them a short 5-minute break or inform them it may take a few minutes to set up the new break out rooms.
- How to set up the new break out rooms:
    - Keep the same groups listed and add additional groups to double the number of groups
        - In a class of 30 people: 8 expertise groups, then add 8 more groups = 16 total groups
        - Assign each person in the first four groups (Groups 1-4) to groups 9-12. Ex. Group 1 has 4 people: 1 person goes to group 9, 1 person to 10, 1 person to 11, 1 person to 12. Group 2 has 4 people: 1 person goes to group 9, 1 person to 10, 1 person to 11, 1 person to 12, etc.
        - Assign each person in the next four groups (Groups 5-8) to groups 13-16. Ex. Group 5 has 5 people: 1 person goes to group 13, 1 person to 14, 1 person to 15, 2 people to 16. Group 6 has 4 people: 1 person goes to group 13, 1 person to 14, 1 person to 15, 1 person to 16, etc.
    - Each group (9-16) should have at least 1 person from each expertise, if done correctly.
- Students will also need to access new “mixed group” slides for break out #3. Only one slide (**slides 9-20** here) will need to be included in each of the group slide sets. Slides 9-12 are the most important and need to be included (as these groups will be sharing their information with the class). The rest may or may not be included depending on # of groups.
- Set the break out room timer at 15 minutes (5 minutes to share expertise, 10 minutes to answer slide questions).
- Tip: Inform the students that there may be some color variation between the Jules Verne Voyager and the maps on the slides and that each person will be reporting out their section to the class once back in the main room.
- As the timer nears its end, copy paste **slide 21** into each groups slides. They will be filling this slide out whilst their peers are presenting.
- When students return, only 4 groups will present their data (those who viewed slides 9-12). Instructor should share their screen so all students can see the “All4Map” presenters are referring to. As they present the different features at each of these locations, the instructor will supplement with anything that was left out by students (10-15 minutes).

Instructor Share Screen:

- Break Out #3 Google slide- ensure all students have access to folder #2 and their new “mixed group” slides.

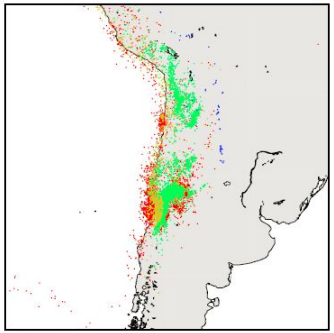
Break Out #3: Types of Plate Boundaries

Your new group should have one person from each specialty now. Have each person in your group explain their specialty (5 minutes / ~1 minute per person) including how they described their specialty at each of the different colors (red, blue, green). Then answer the following questions about your specialties along a specific plate boundary (map below).

1. What type of plate boundary are you looking at?
2. How do earthquakes behave along this boundary?
3. How would you describe volcanoes along this boundary?
4. What ages of seafloor are found along this boundary?
5. What is the topographic relief (elevation) along this boundary?

Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



Earthquakes

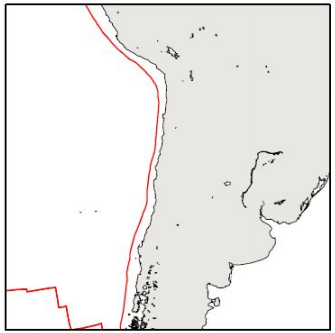
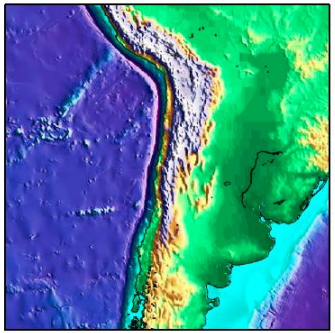
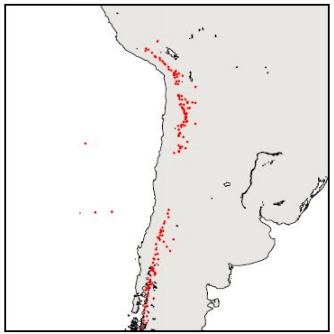


Plate Boundaries



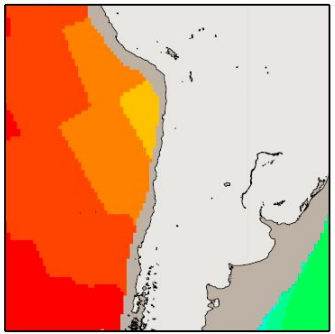
Topography



Volcanoes

Convergent Plate Boundary
Chile

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

Your new group should have one person from each specialty now. Have each person in your group explain their specialty (5 minutes / ~1 minute per person) including how they described their specialty at each of the different colors (red, blue, green). Then answer the following questions about your specialties along a specific plate boundary (map below).

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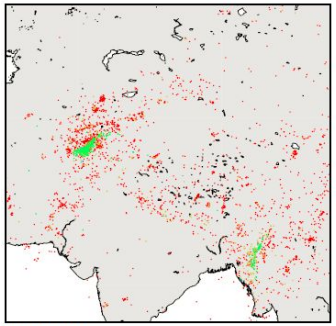
Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



Earthquakes

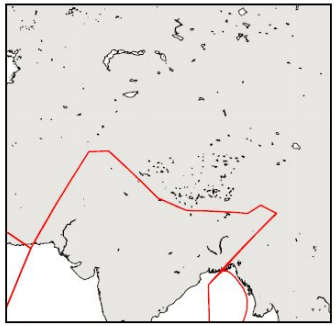
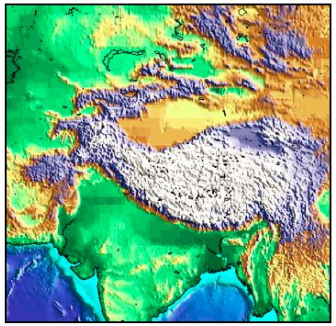
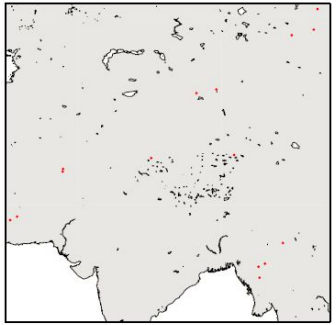


Plate Boundaries



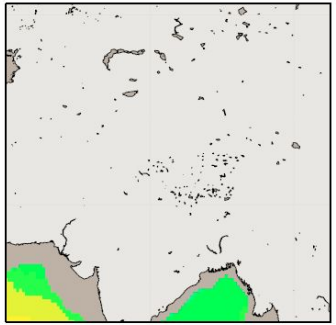
Topography



Volcanoes

Convergent Plate Boundary
India/Tibet

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

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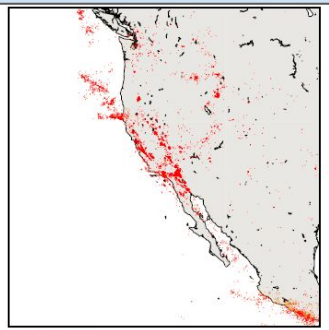
Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



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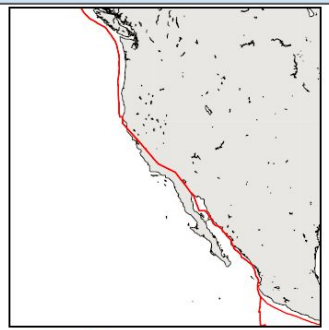
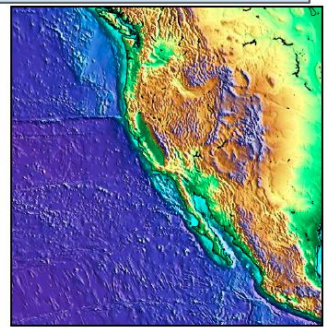
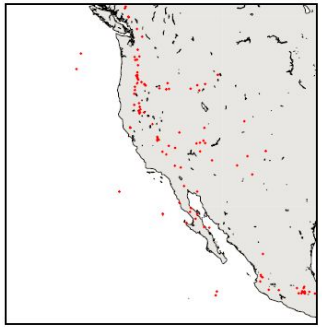


Plate Boundaries



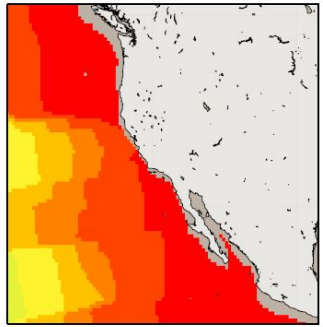
Topography



Volcanoes

Transform Plate Boundary
Western North America

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

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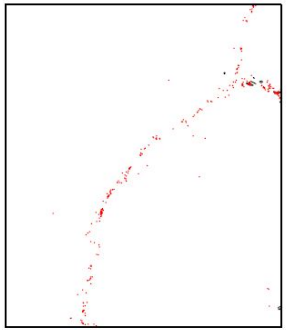
Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



Earthquakes

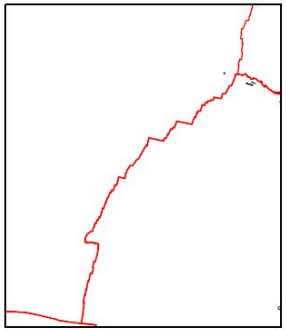
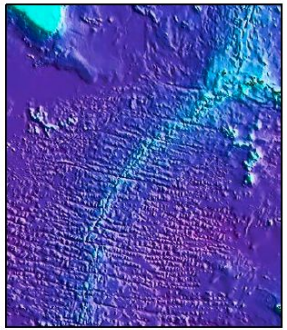
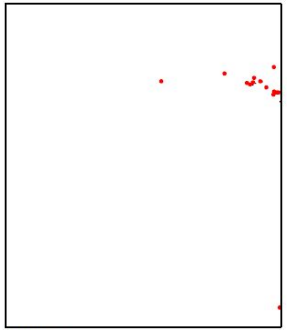


Plate Boundaries



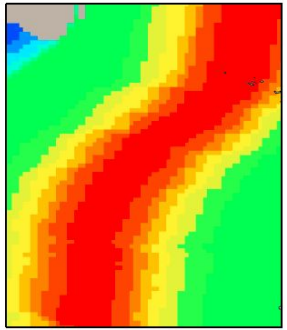
Topography



Volcanoes

Divergent Plate Boundary
Mid-Atlantic Ridge

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

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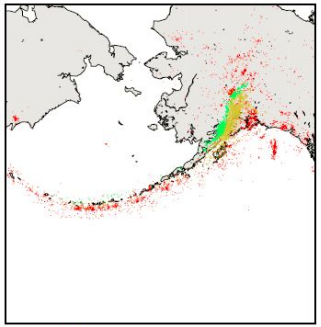
Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



Earthquakes

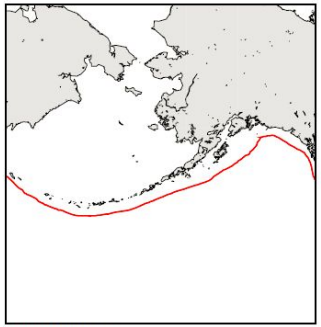
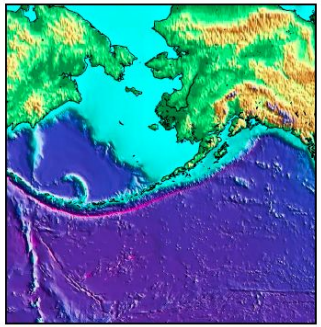
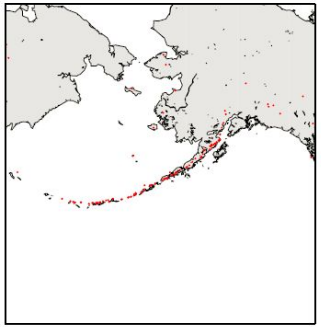


Plate Boundaries



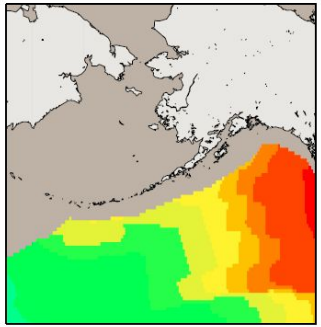
Topography



Volcanoes

Convergent Plate Boundary
Aleutian Arc

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

Your new group should have one person from each specialty now. Have each person in your group explain their specialty (5 minutes / ~1 minute per person) including how they described their specialty at each of the different colors (red, blue, green). Then answer the following questions about your specialties along a specific plate boundary (map below).

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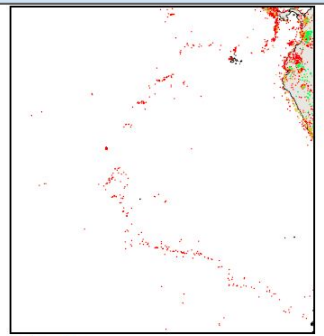
Remember: Each group will be presenting their new plate boundary to the class and each person will present their specialty!

Type Answers Here!



Earthquakes

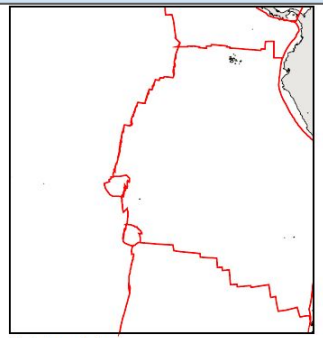
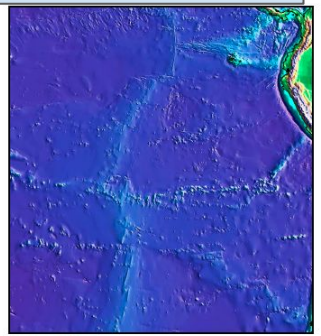
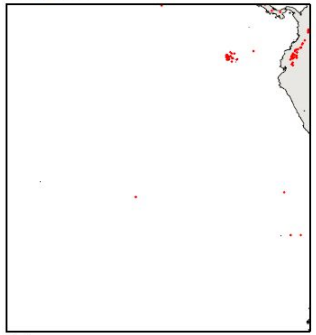


Plate Boundaries



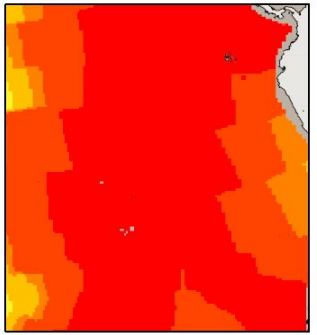
Topography



Volcanoes

Divergent Plate Boundary
East Pacific Rise

https://plateboundary.rice.edu/



Seafloor Age

Break Out #3: Types of Plate Boundaries

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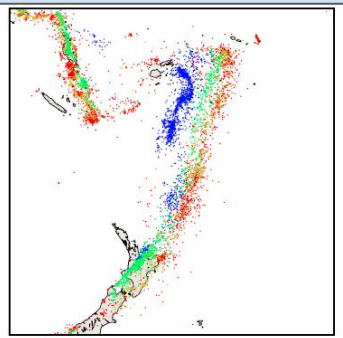


Earthquakes

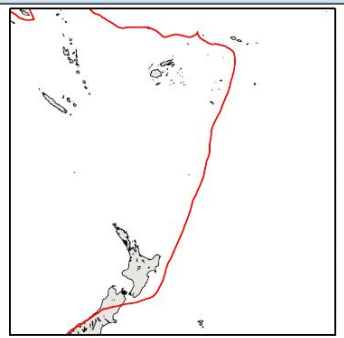
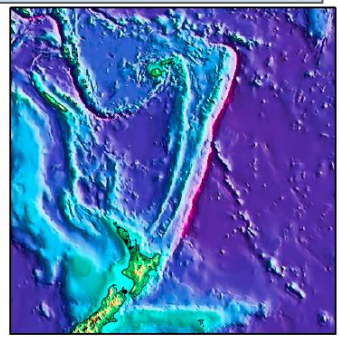
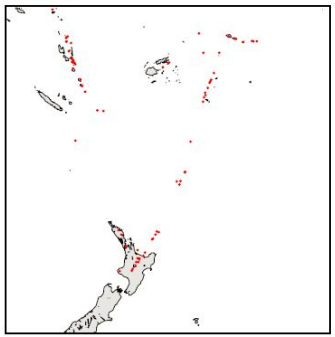


Plate Boundaries



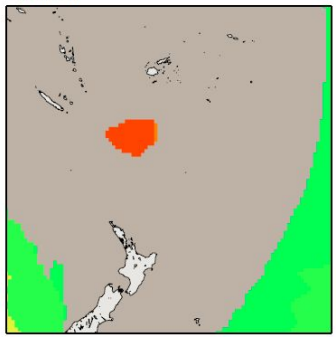
Topography



Volcanoes

Convergent Plate Boundary
Fiji/Tonga

https://plateboundary.rice.edu/



Seafloor Age

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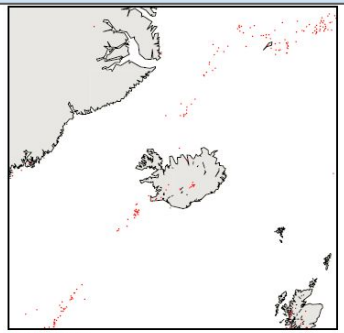

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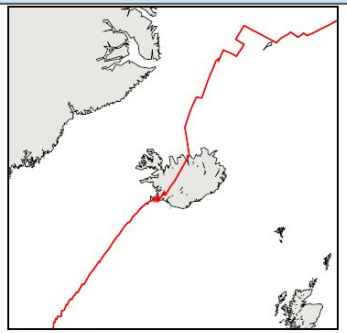
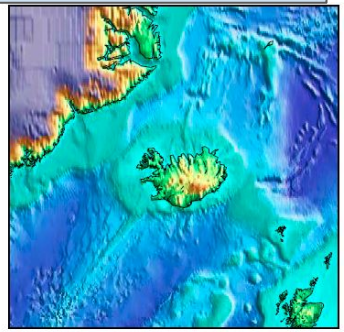


Plate Boundaries



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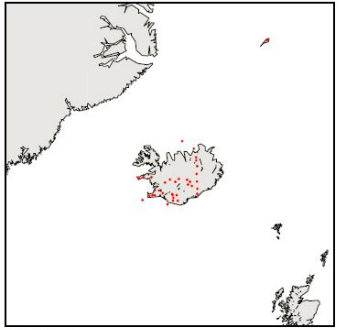
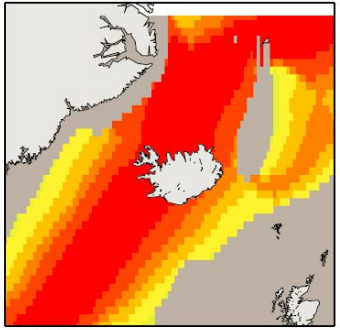


Volcanoes

Divergent Plate Boundary
Iceland and Mid-Atlantic Ridge

https://plateboundary.rice.edu/



Seafloor Age

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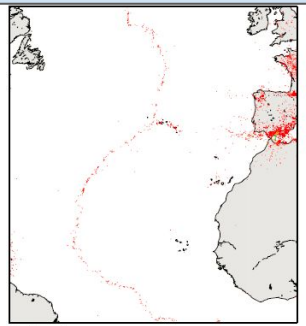


Earthquakes

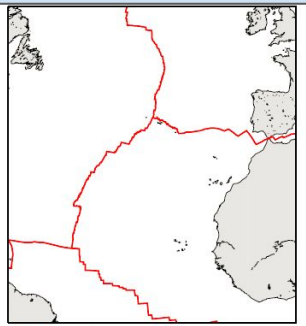
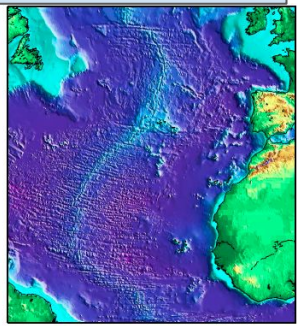


Plate Boundaries



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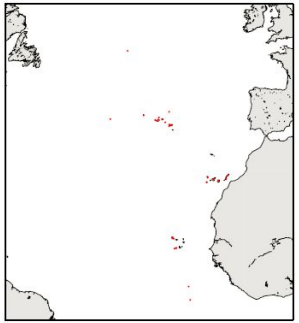
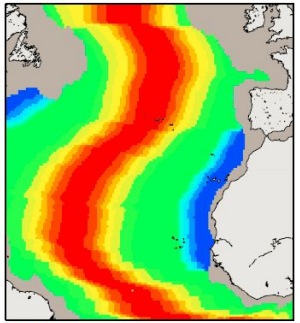


Volcanoes

Divergent Plate Boundary
Mid-Atlantic Ridge

https://plateboundary.rice.edu/



Seafloor Age

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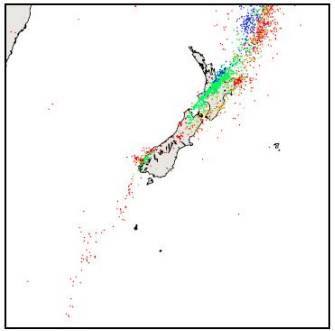
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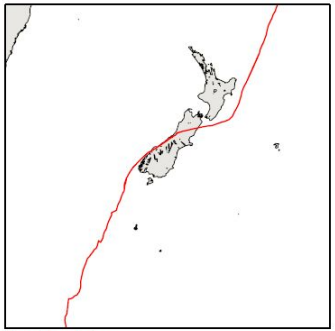
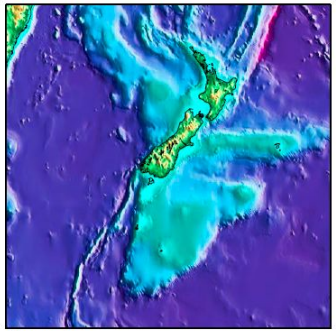


Plate Boundaries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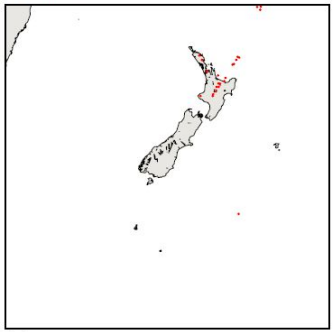
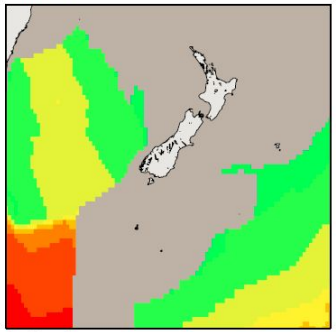

Volcanoes

Transform Plate Boundary
New Zealand

https://plateboundary.rice.edu/


Seafloor Age

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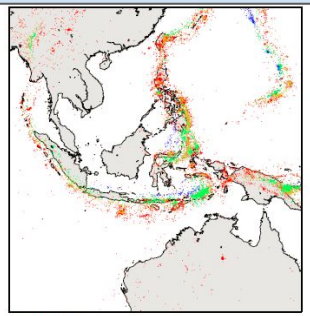

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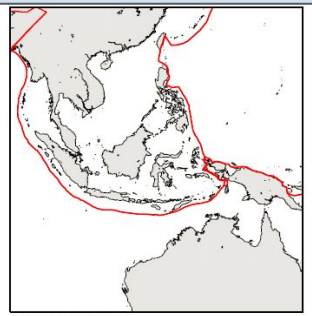

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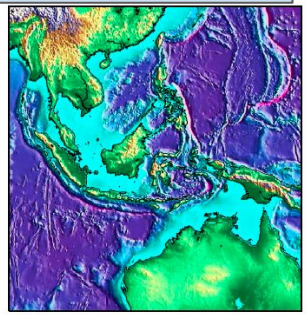

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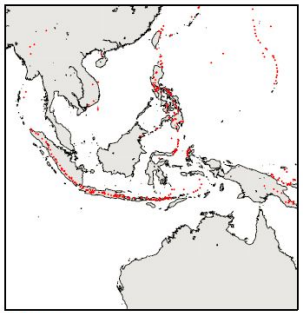
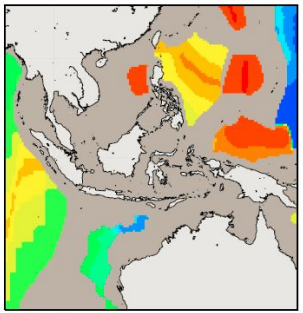


Volcanoes

Convergent Plate Boundary Southeast Asia

https://plateboundary.rice.edu/



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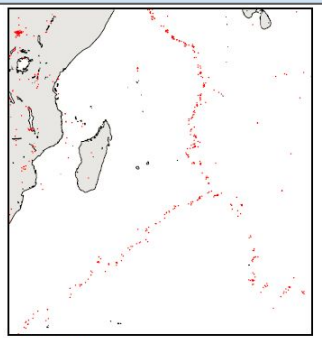

Earthquakes

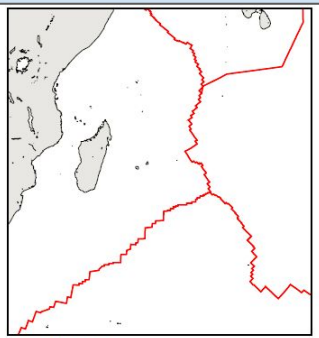
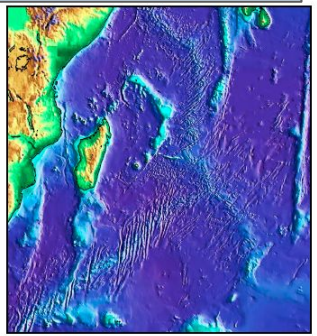


Plate Boundaries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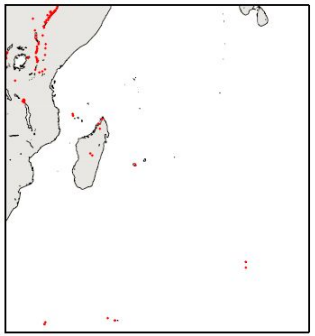
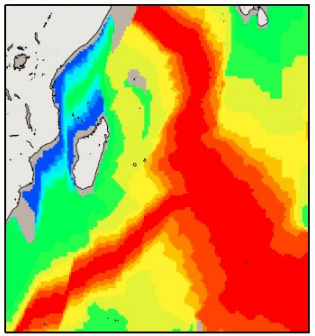
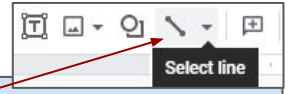

Volcanoes

Divergent Plate Boundary
Southwest Indian Ridge

https://plateboundary.rice.edu/


Seafloor Age

Lecture Notes: Types of Plate Boundaries



As groups are presenting on their plate boundaries, use the chart below to fill in pertinent information. You may wish to use the scribble tool to draw arrows. This can be found by clicking on the line button on the toolbar.

Type of plate boundary	Plate movement	Description of what is happening at the plate boundary	Hazards found	Example- Where can you see this?
Convergent with subduction	Click here to type!			
Convergent				
Divergent				
Transform				

Instructor Slide Guide:

The following slides (23-33) are the “mystery plate boundary” slides. Students will stay in their mixed groups and use their newfound knowledge to determine which type of plate boundary they are viewing and interpret the type of margin, hazards, and draw a cross section one would find at their location.

Recommended Actions:

- As the four groups are explaining their slides, copy/paste a different “mystery plate boundary” (**slides 23-33** here) to each group’s slides for break out #4.
- Set the break out room timer at 20 minutes
- Once students have made significant headway on answering the questions, copy/paste slide 34 into their group’s slides.
- Tip: Instructors may choose to go over one of the following slides as a class to use as an example before setting students off into the break out rooms.
- Tip: Explain different features of an active/passive margin and how to identify them on a map.
- Tip: Discuss what a cross section is and how to infer what one looks like based off of topographic data.

Instructor Share Screen:

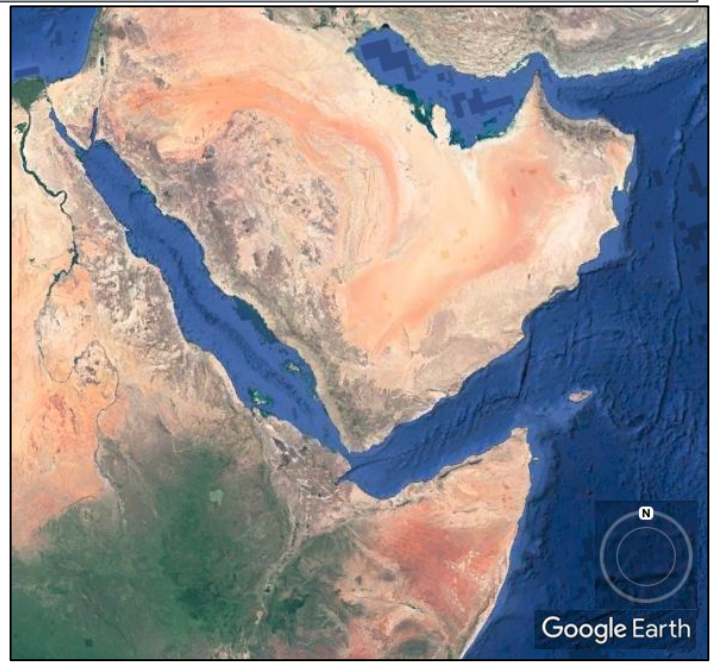
- Break Out #4 Google slide- ensure all students have access to the mystery plate boundary slide in their shared Google slideset.
- Instructor should explain what a cross section is and show students how to use the “scribble tool” on Google slides to create a rough sketch of a cross section.

Break Out #4: Mystery Plate Boundary

In groups, view the assigned region of Earth (below) and together with your team determine its plate tectonic setting using topographic changes and geographic features as your clues.

1. What is the geographic location of your mystery region?
2. Identify changes in elevation (above and below sea level) and list them.
    - Hint: focus on features that may help you interpret the plate tectonic setting of your region.
3. What is the plate tectonic setting of your region? Be very detailed (“convergent” is not enough)
4. Would it be likely for your areas to experience earthquakes? Why/why not?
5. What are active/passive continental margins? Are there active and/or passive continental margins in your general region? If so, how did you identify them?
6. How would you figure out how fast these plates are moving? What additional information would you need?

Type Answers Here!



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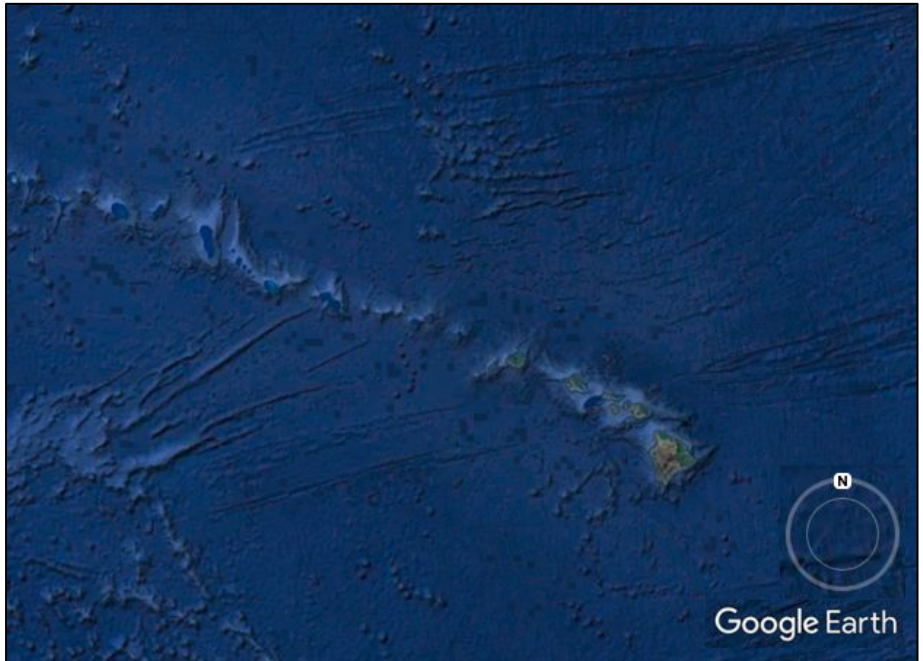

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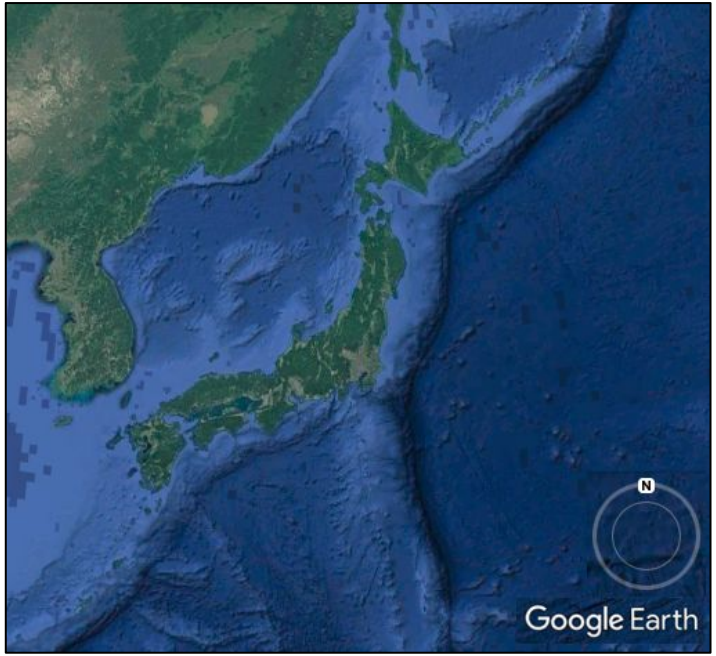

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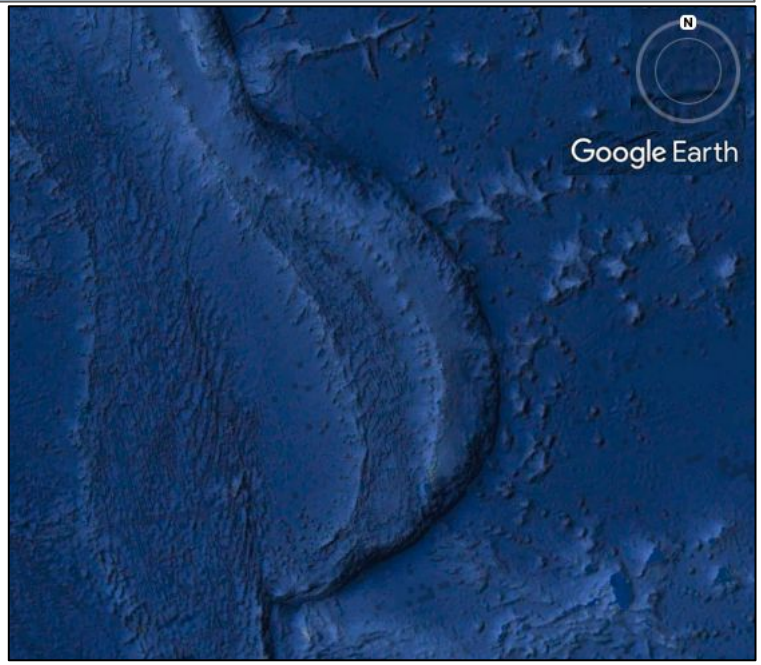
Type Answers Here!

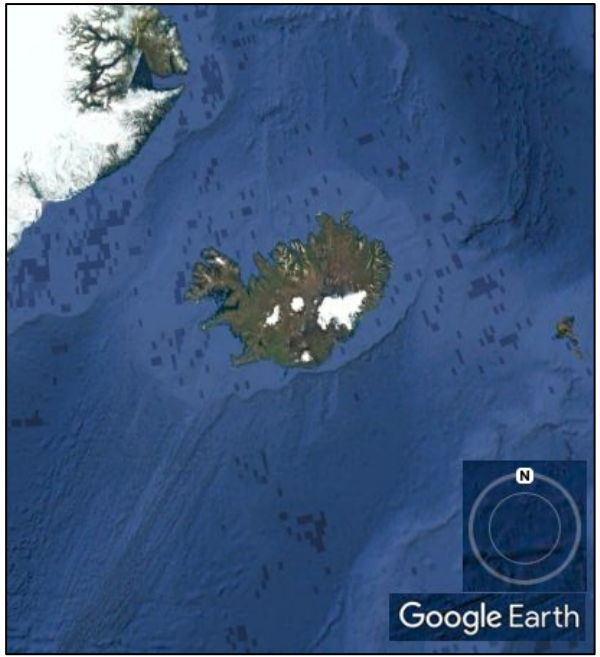


Break Out #4: Mystery Plate Boundary

In groups, view the assigned region of Earth (below) and together with your team determine its plate tectonic setting using topographic changes and geographic features as your clues.

1. What is the geographic location of your mystery region?
2. Identify changes in elevation (above and below sea level) and list them.
    - Hint: focus on features that may help you interpret the plate tectonic setting of your region.
3. What is the plate tectonic setting of your region? Be very detailed (“convergent” is not enough)
4. Would it be likely for your areas to experience earthquakes? Why/why not?
5. What are active/passive continental margins? Are there active and/or passive continental margins in your general region? If so, how did you identify them?
6. How would you figure out how fast these plates are moving? What additional information would you need?

Type Answers Here!



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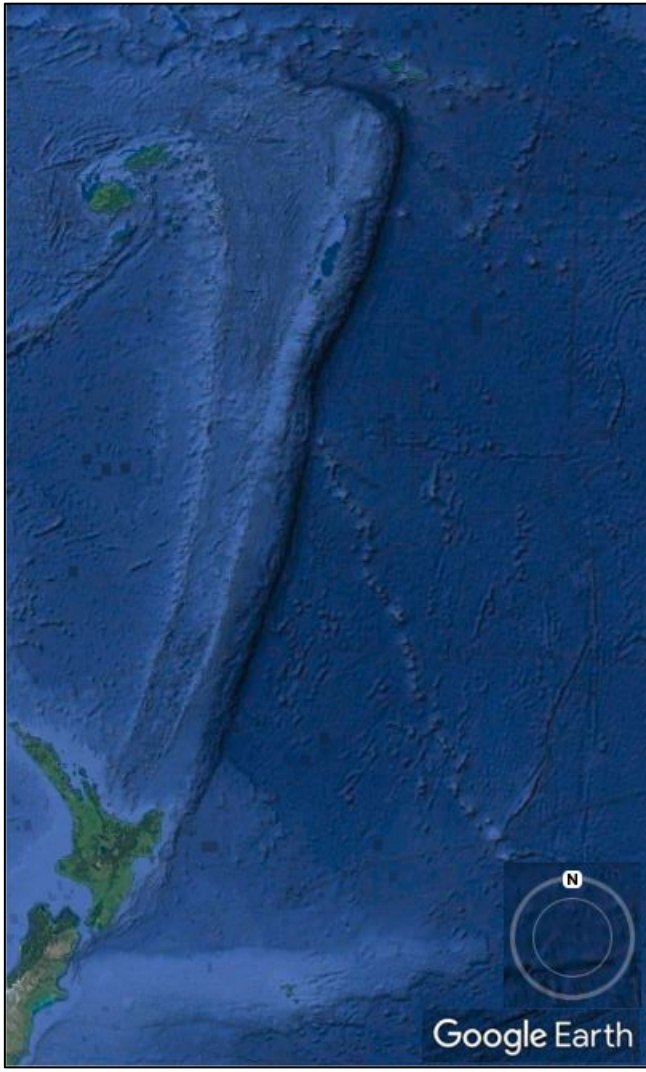
Type Answers Here!



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    - Hint: focus on features that may help you interpret the plate tectonic setting of your region.
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Type Answers Here!

Break Out #4: Mystery Plate Boundary

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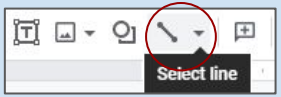
Type Answers Here!

Break Out #4: Mystery Plate Boundary Continued

Sketch a cross-sectional view (side-view) through your area, which shows the important features of your tectonic setting. You may wish to use the scribble tool to draw arrows. This can be found by clicking on the line button on the toolbar. Your drawing should include the following:



1. Clearly labeled plates (oceanic or continental; names of plates)
2. Arrows indicating direction of motion of the plates
3. Labeled topographic features, such as mountains, trenches, volcanoes

Instructor Slide Guide:

Groups will now work with GPS data to visualize the direction and speed of plate motion across the globe.

Recommended Actions:

- Instructor may consider having students watch the following video before or during this class session:
  - Measuring Plate Tectonics with GPS
- Set break out room timer to 25 minutes.

Instructor Share Screen:

  - Break Out #5 Google slide and map- ensure all students have access to the GPS data and Dynamic Planet map slides in their shared Google slideset.
  - Instructors should re-introduce GPS vectors and demonstrate how to draw them in the Google slides before sending students into their breakout rooms.

Break Out #5: GPS Data and Plate Motion

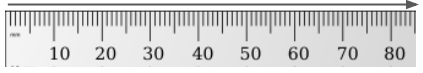
In this activity, your group will use GPS data to see how plates move over time. GPS stations are located throughout the world, and linked to satellites in fixed orbits around the earth. Data about the location of these stations has been collected for many years and using it, we can see that continents and plates have moved over time. The chart below gives GPS data for 12 locations around the world, with the average distance moved by each station in one year, and the direction it moved. Notice that the direction is given as either east or west of north and the scale for the length of the arrow is given below.

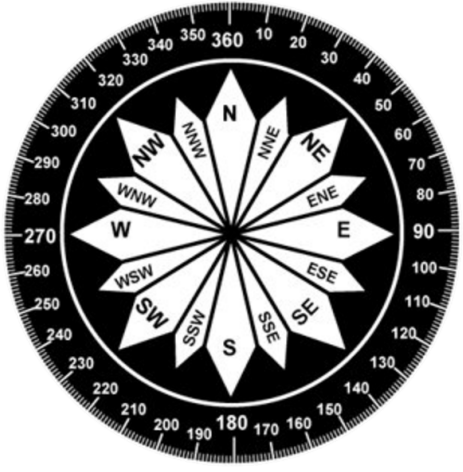
Using the data on this page, annotate the USGS This Dynamic Planet map on the next slide:

1. Find the locations listed below on the map (next slide), draw an arrow indicating the direction of movement. Build rough vectors of direction and distance. The length will represent the amount of movement (use the scale arrow for guidance) and the angle will represent the direction of movement from North (use the compass rose for guidance). The first location has been done for you!
2. Have a look at the map and note relative movements. Discuss which geographical features can be related to plate movement.

Location	Distance: mm per year	Direction: Degrees from North
Canberra, Australia	58	18E
Guam, Indonesia	11	77W
Hawaii, USA	72	60W
Ulaanbaatar, Mongolia	25	100E
Buenos Aires, Argentina	12	10W
Oslo, Norway	21	50E
Denver, USA	17	103W
Capetown, South Africa	21	36E
St. Johns, Canada	19	51W
Yellowknife, Canada	21	125W
Bangalore, India	50	35E
Madrid, Spain	23	44E

Scale





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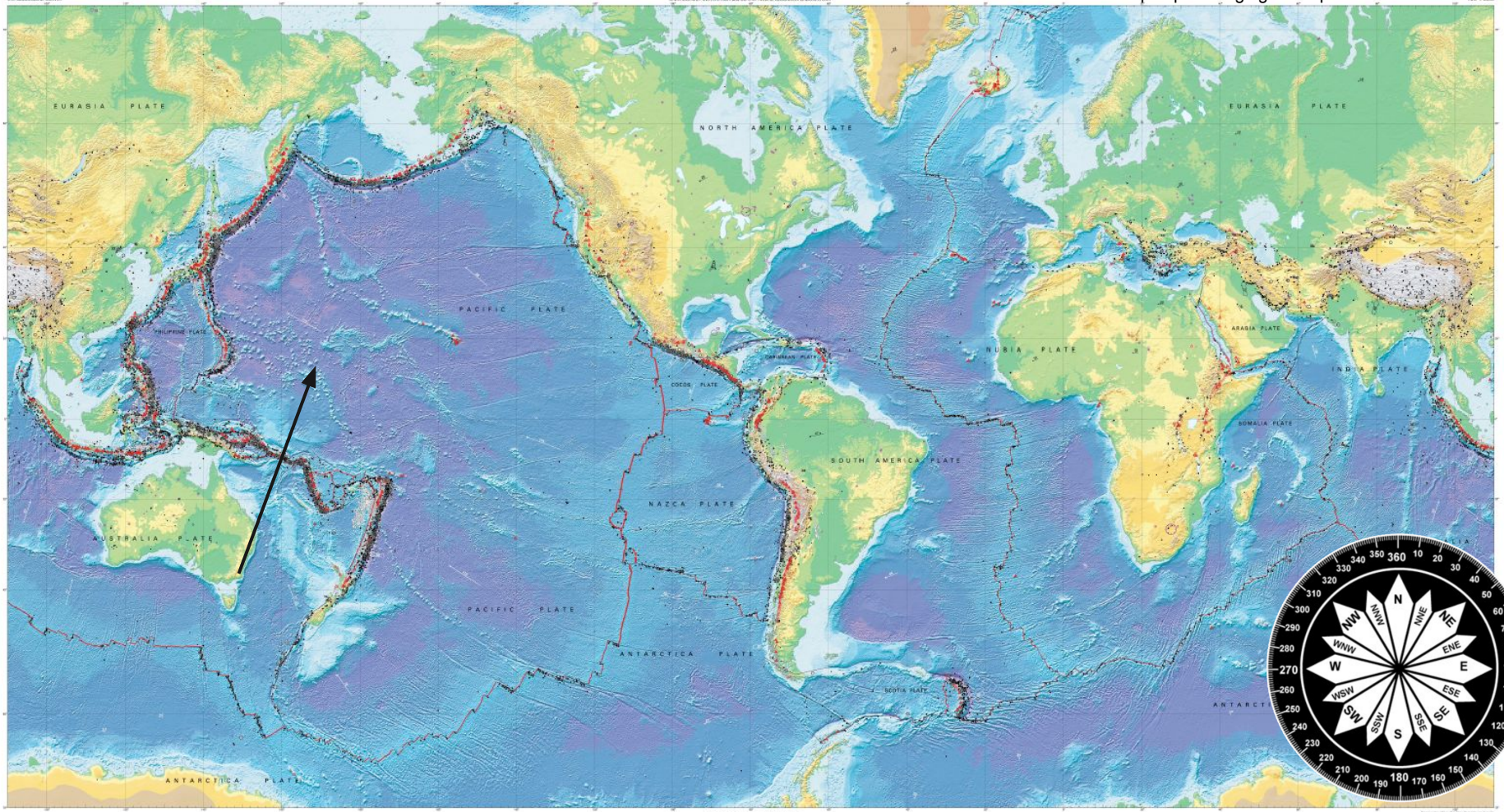
https://pubs.usgs.gov/imap/2800/



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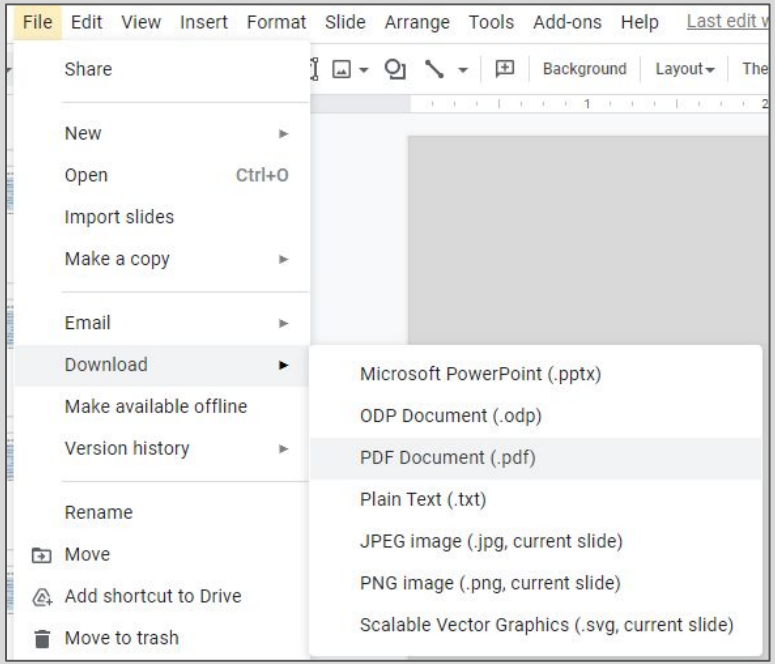
Instructor Slide Guide:

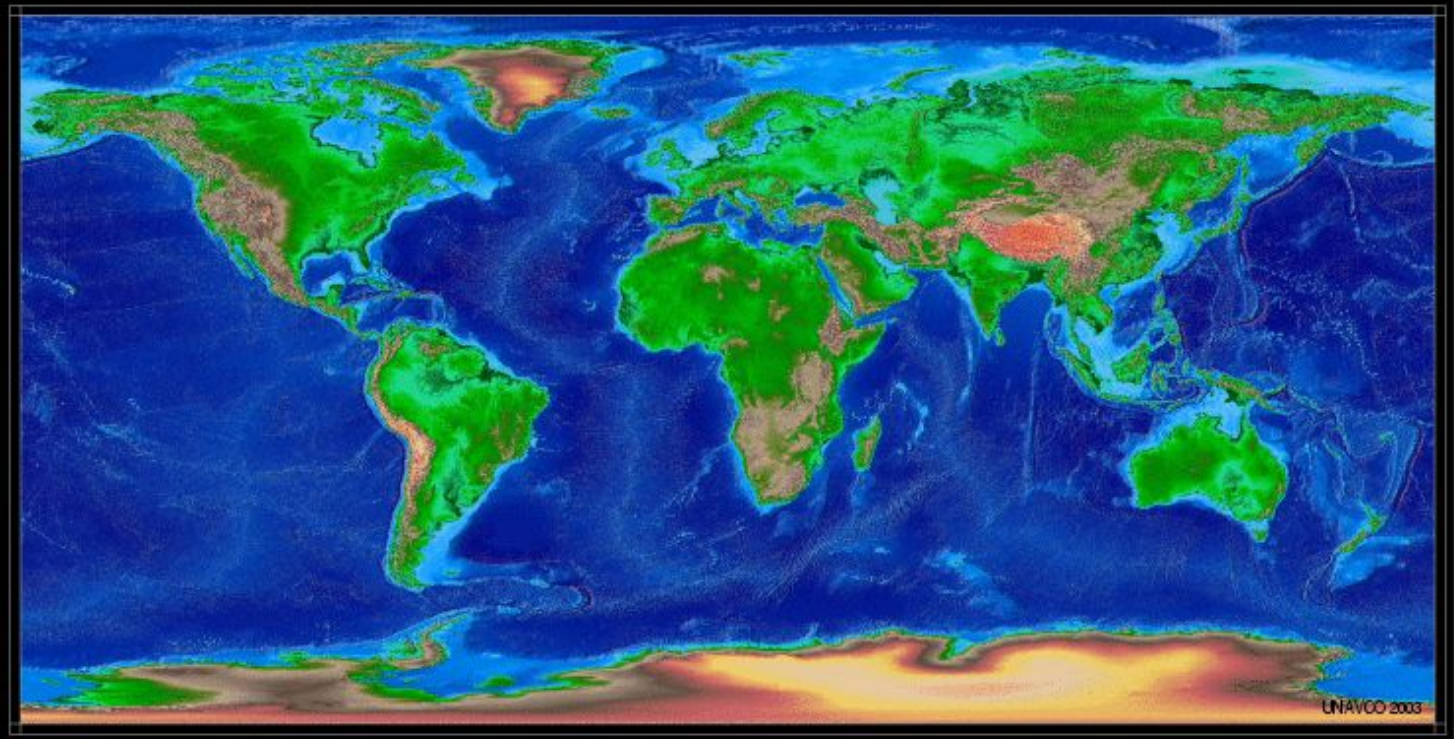
End of class session. Students will download both slide sets (expert and mixed) as PDFs (see screenshot below) and submit on LMS. In class participation is worth 5 points. Students will receive full credit for completed submissions with detailed and thoughtful responses. Partial credit will be given if slides are missing or incomplete.

Recommended Actions:

- Students may watch the following videos to reinforce what they learned in class:
  - Plate Tectonics Basics
  - Transform Plate Boundaries
  - Divergent Plate Boundaries (or How do you make an ocean?)
  - Convergent Plate Boundaries
  - Measuring Plate Tectonics with GPS
- Supplemental Activities may be assigned for homework or can allow for this lab to be extended.
- Exit Ticket can be administered as a quiz on the LMS.



Jules Verne Voyager- Topography



Color Topography
(Elevation & depth from mean sea level in meters)

8622
6000
5000
4200
3700
3200
2700
2200
1700
1200
800
600
400
200
100
0
-1
-20
-40
-80
-200
-400
-800
-1600
-2800
-4000
-6000
-8000
-10644

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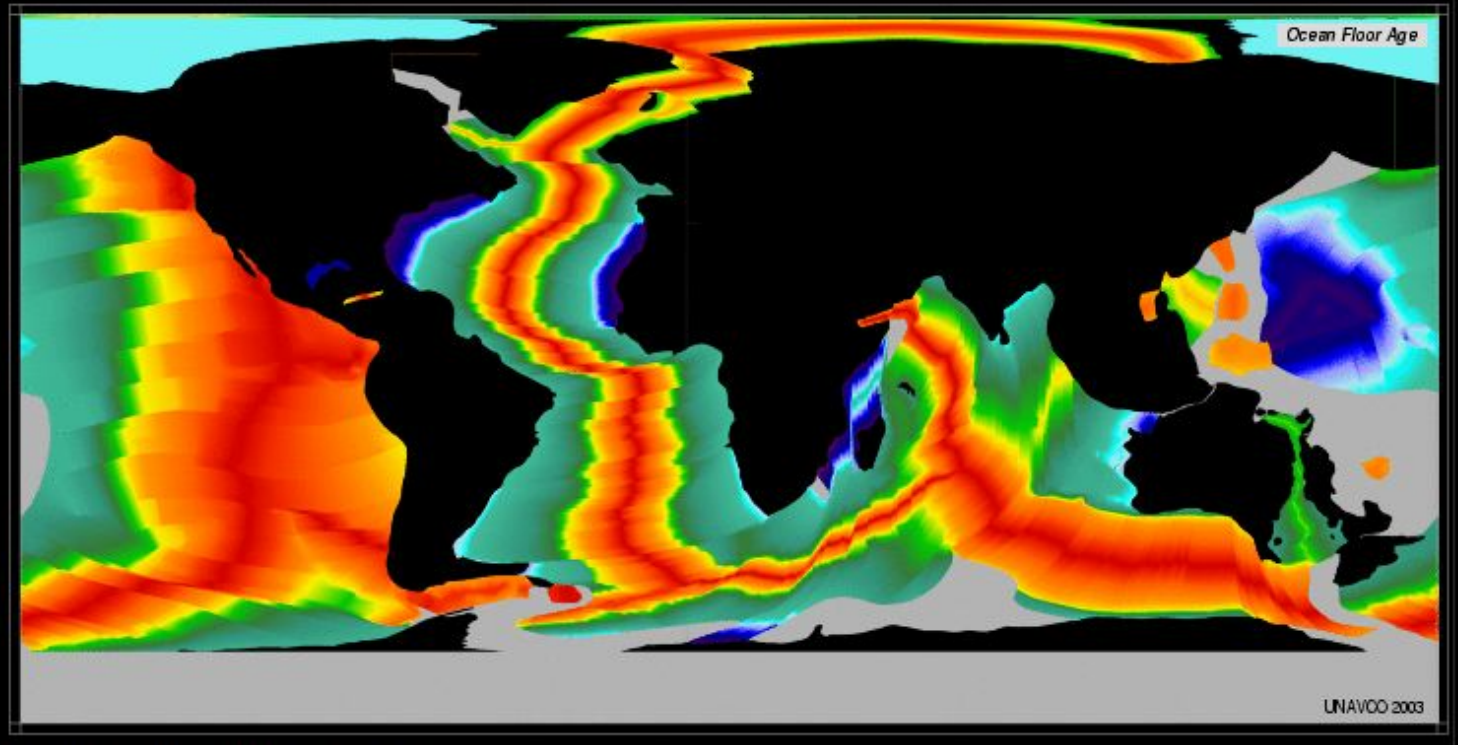
Jules Verne Voyager- Seafloor Age



Ocean Floor Age In Millions of Years

0
10.9
20.1
33.1
40.1
47.9
55.9
67.7
83.5
120.4
126.7
131.9
139.6
147.7
154.3
180

Areas with no data are gray. Oceanic areas in black are mostly continental crust currently below sea level.

Comments: webmaster@ unavco.org

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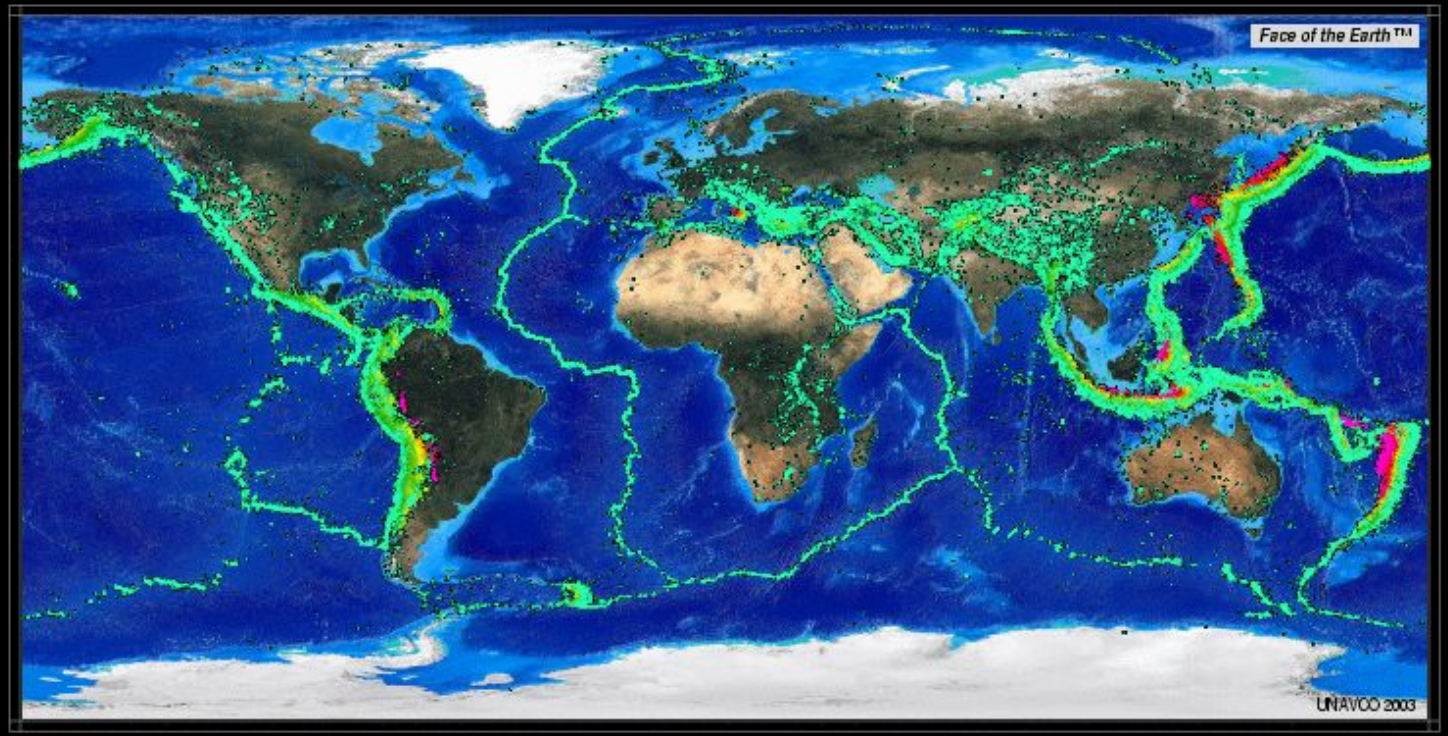
Jules Verne Voyager- Earthquakes



Earthquake Depth (km)

- 0-33
- 50
- 120
- 200
- 300
- 400
- 500
- 670
- 750

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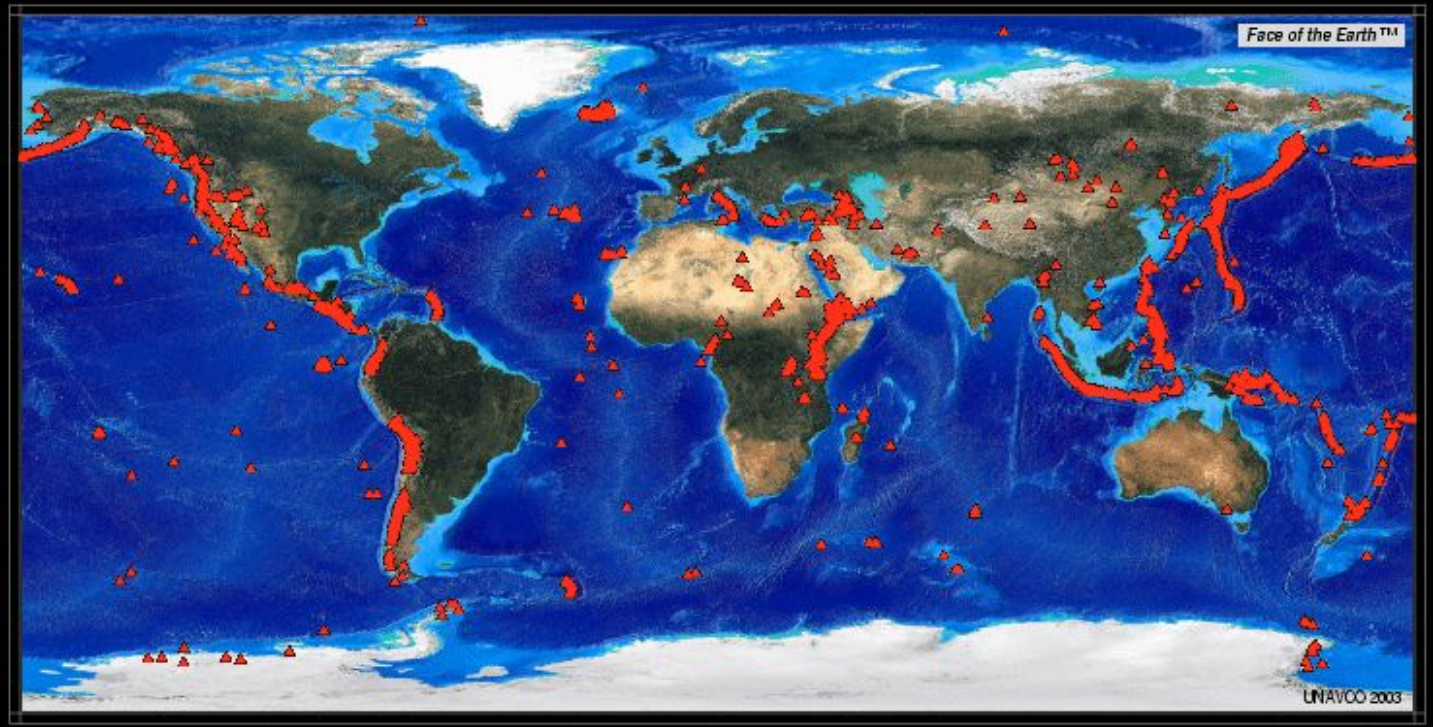
Jules Verne Voyager- Volcanoes



Volcanoes

Red triangles = Active volcanoes, i.e., eruptions within the last 10,000 years (Holocene time)

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