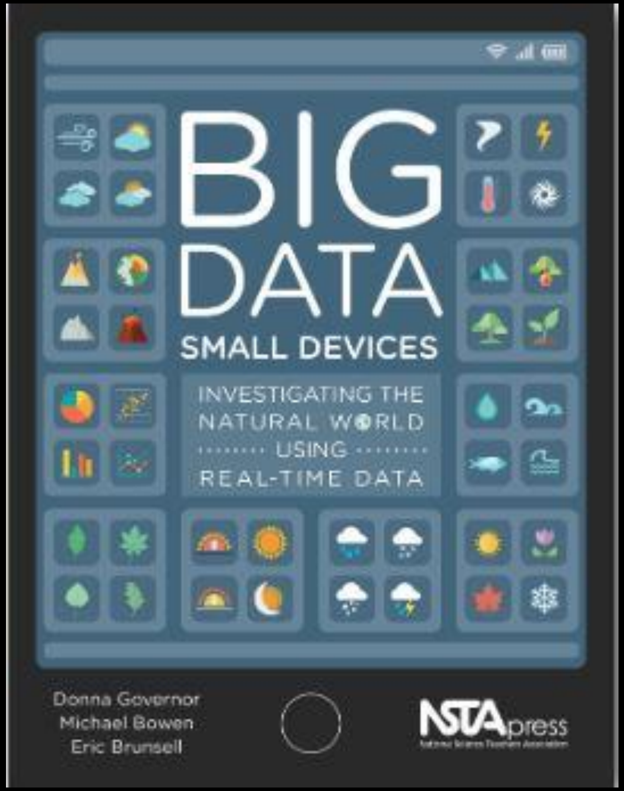


Dr. Sebastian Szyjka

BIG DATA, SMALL DEVICES [EARTH SCIENCE: EARTHQUAKE DATA AND TECTONIC PLATES]

What is Real-time Data?

- Earth Science, Earthquakes and Theory of Plate Tectonics
- Traditional vs. Real-time data
- Advantages of Real-time data
- Patterns, Relationships, making inferences with data
- Note about time

Table 2.1. UTC conversion to U.S. time zones

U.S. Time Zone	EST	EDT	CST	CDT	MST	MDT	PST	PDT
Difference from UTC (hour)	-5	-4	-6	-5	-7	-6	-8	-7

CST = Central Standard Time
CDT = Central Daylight Time
EST = Eastern Standard Time
EDT = Eastern Daylight Time
MST = Mountain Standard Time
MDT = Mountain Daylight Time
PST = Pacific Standard Time
PDT = Pacific Daylight Time

Accessing Real-Time Data for Investigations

- Tracking Earthquake and Volcanic activity to learn about plate locations and their relationship to plate boundaries
- (NGSS: patterns, cause & effect, stability & change)
- Teaching digital natives
- Use of smartphones, computers, and accessing URLs for data
- https://earthquake.usgs.gov/earthquakes/map/

Delivery Modalities

- Operating systems
- Responsive Design
- Native Apps
- Finding Apps
- QR Codes

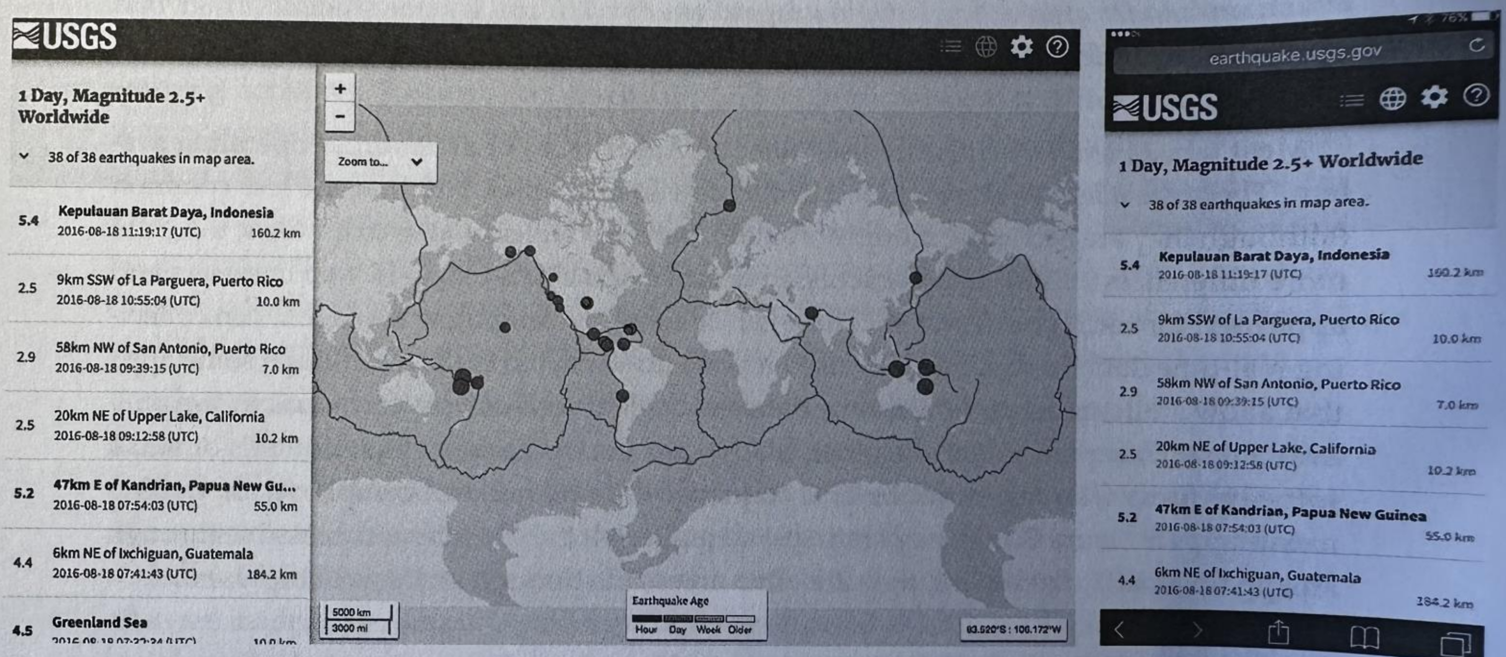


Figure 2.1. Screenshot of the USGS *Earthquake* website on a laptop screen (left) and a smartphone (right), showing how websites designed to be responsive adapt to the screen size of the device being used

Source: U.S. Geological Survey. *http://earthquake.usgs.gov/earthquakes/map.*

Visual Representation of Data

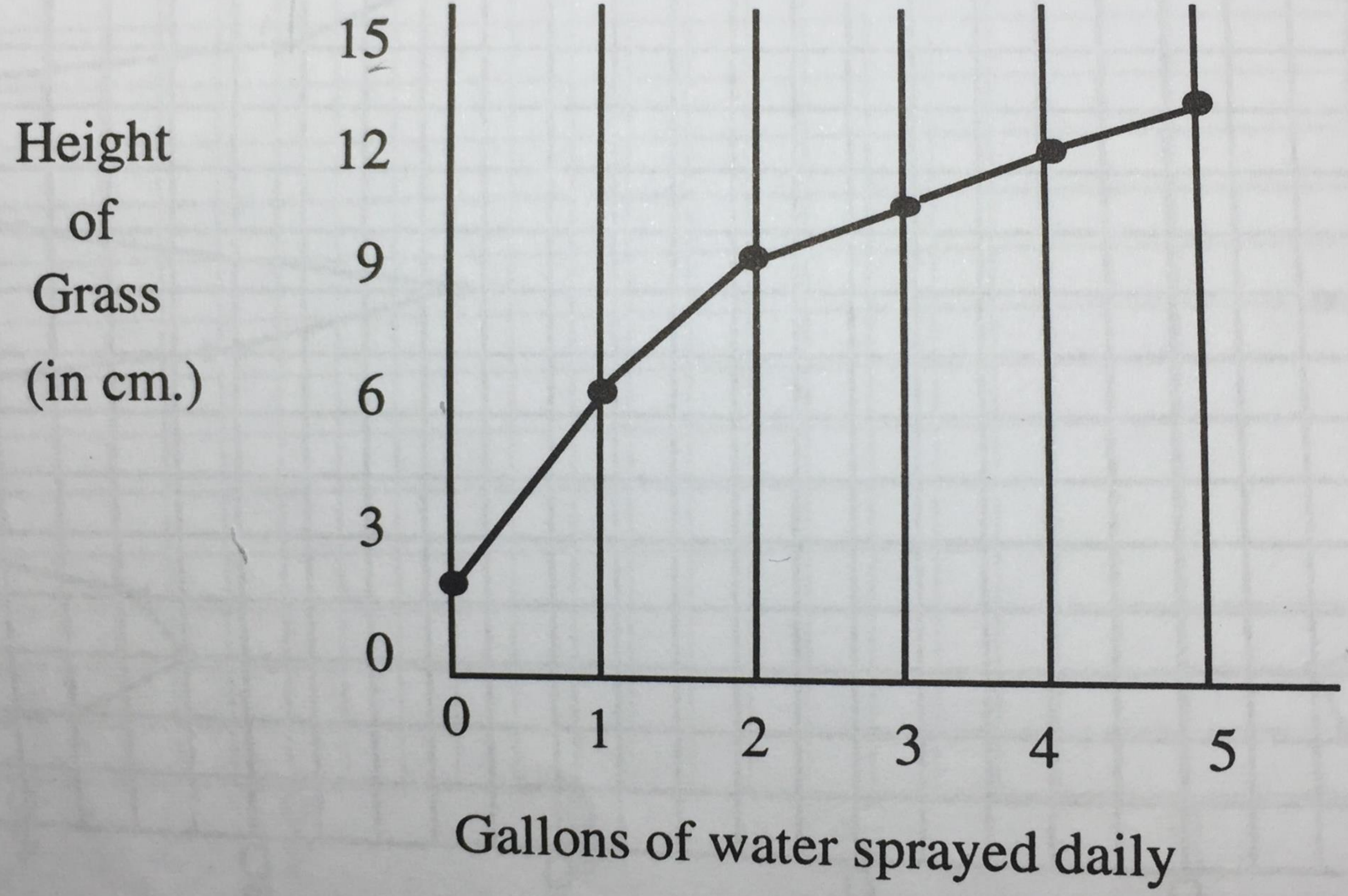
- Charting
- Graphic organizer
- Graphing
- Mapping data
- Spreadsheets (excel, Google sheets)

Rules for Graphing (Line) Continuous measured data

The coordinate or line graph: The coordinate or line graph is typically used to show increases or decreases in variables or to show change in variables over time. Here we are involved with data which can be displayed in a continuous line or set of lines.

1. The graph should have a title that is succinctly but adequately describes the relationship between the graphed variables.
2. The symmetrically changing variable, in experimental data this is the independent or manipulated variable, is presented on the horizontal axis.
3. The data which represents the observe results, in an experimental setting this is the dependent or responding variable data, should be presented on the vertical axis.
4. Both accessories should be labeled to identify which information or variable each represents.
5. All intervals on the axis should be numbered so that they are equal and continuous.
6. Coordinates or data must be plotted accurately.

HEIGHT OF GRASS IN SIX DIFFERENT PLOTS AFTER 10 DAYS OF BEING SPRAYED DAILY WITH DIFFERENT AMOUNTS OF WATER



Rules for Graphing (Bar) Nominal (categorical data)

The bar graph. If the need is to graph number data related to categories, such as different school subjects or types of music, then a bar graph is used.

1. The graph should have a clear title, describing what the graph data is presenting.

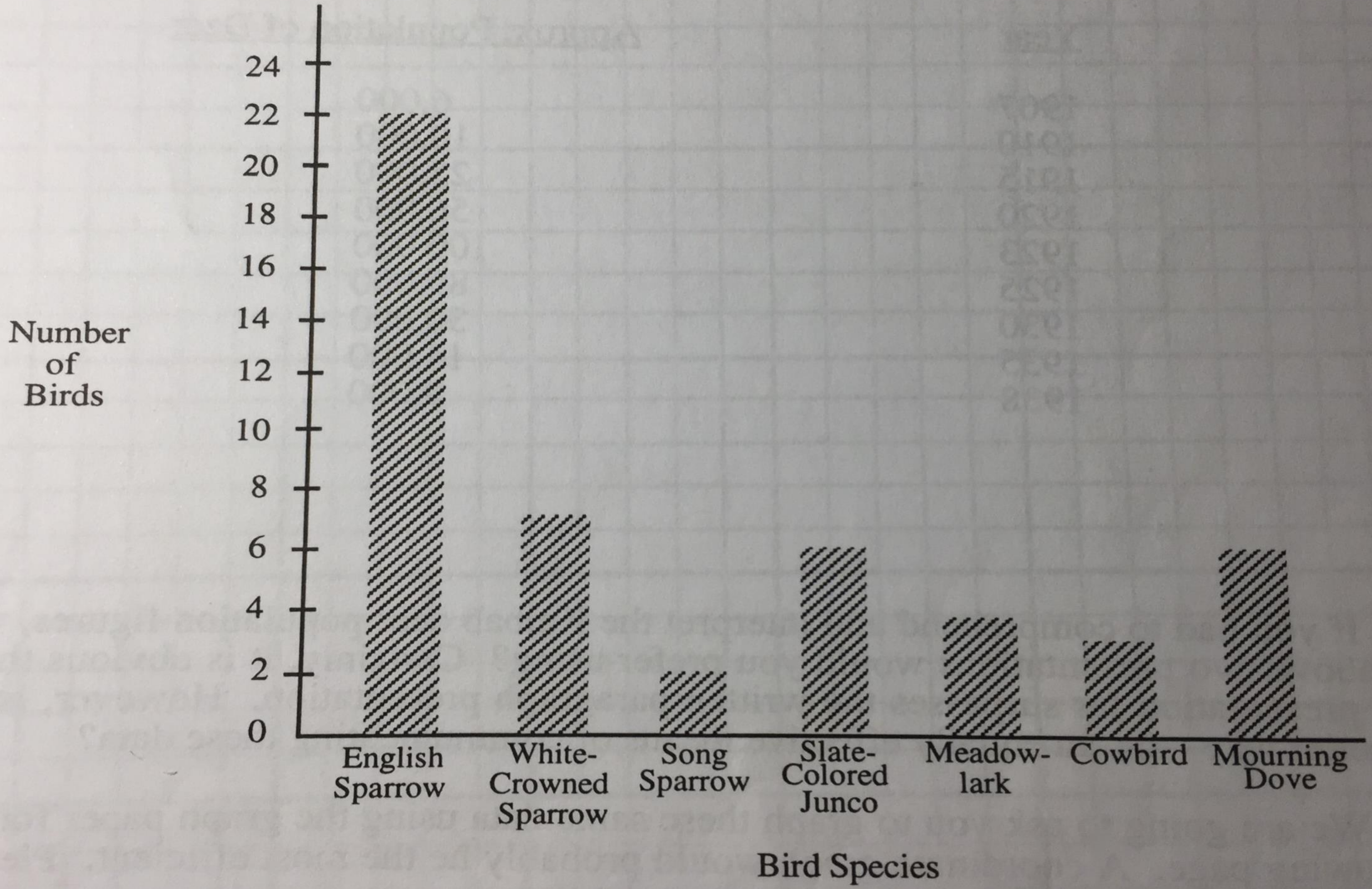
2. The specific categories are presented on the horizontal axis, also known as the X axis.

3. Number intervals identified on the vertical axis, also called the Y axis, should be equal and continuous.

4. Both axes should be labeled to indicate what information each represents.

5. The actual data must be plotted accurately.

NUMBER OF BIRDS, BY SPECIES, OBSERVED AT THE JOHNSON'S FEEDING STATION AT 8 AM ON JANUARY 21, 1984



Science and Engineering Practices

- Asking Questions and defining problems
- Analyzing and interpreting data (inferences, variables, relationships between variables, hypothesis generation, etc.)
- Making sense of data
- Constructing explanations (supporting claims with data)
- Obtaining, evaluating, and communicating information

Engaging in argument from evidence (types of plate interactions)

Table 3.3. USGS 30-day earthquake data for May 19, 2017, through June 10, 2017 (lat = latitude; long = longitude)

Date	Lat S	Long W	Depth (km)	Magnitude
5/19	-19.8	-174.0	14.4	4.5
5/20	-23.9	-179.7	492.1	4.5
5/22	-18.7	-172.7	10.0	5.1
5/22	-24.0	-179.8	530.3	4.6
5/25	-22.4	-176.3	110.2	5.3
5/26	-21.0	-178.7	561.8	5.0
5/29	-21.4	-178.5	554.6	4.6
5/30	-21.4	-176.6	182.1	4.6
6/1	-19.7	-173.4	10.0	4.8
6/5	-21.3	-178.2	448.8	4.5
6/9	-23.1	-176.8	176.8	4.7
6/10	-18.6	-173.1	64.3	4.6

Data source: U.S. Geological Survey. *http://earthquake.usgs.gov.*

Example of Investigations [Earth & Environmental Science]

- Atmospheric Data
- Geosphere Data (Convergent or Divergent?, Radon Mapper, Tectonic Plates shuffle, Volcano Risk) [Geology]
- Biosphere Data
- Hydrosphere Data
- Celestial Sphere Data

Geosphere Data (Convergent or Divergent)[Geology]

- Earth Science is the study of planet Earth, including its structure, components, and essential characteristics.

Classification of topics in Earth Science include:

(1) Geography (landforms, features and climates);

(2) Geology (study of the crust of Earth, including its components and development);

(3) Oceanography (study of Earth's water –fresh and salt)

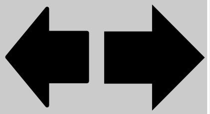
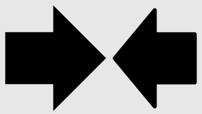
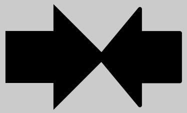
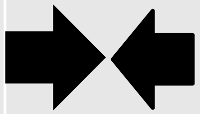
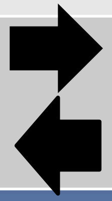
Theory of Plate Tectonics

- Plates interact by colliding into, moving away from, and rubbing against each other. These interactions create earthquakes, volcanoes, and mountain ranges (Divergent plates, Transform plates, and Convergent plates).
- Seafloor spreading is a process that occurs at mid-ocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.
- Seafloor spreading helps explain continental drift in the theory of plate tectonics.

How plate Tectonics Work,
In 2.5 minutes. Your Welcome.

http://www.huffingtonpost.com/2015/01/19/plate-tectonics-explained-video_n_6487420.html

Tectonic Organizer (o= Oceanic; C=Continental)

Tectonic boundary	Symbol	Stress	Lithosphere effect	Earthquakes?	Volcanoes?	Faults and folds	Other features/ Location
Divergent		Tension	Creation	Yes	Yes	Normal faults	Rift valleys/ Great Rift Valley Africa
Convergent (o-o)		Compression	Destruction	Yes	Yes	Folding, reverse faults	Volcanic Islands/
Convergent (o-c)		Compression	Destruction	Yes	Yes	Folding, reverse faults	Volcanic Islands/ Marianas Trench in Pacific, Puerto Rico Trench Atlantic
Convergent (c-c)		Compression	Destruction	Yes		Folding, reverse faults	Mountains/ Himalayas, Alps, Appalachian
Transform		Shear	Conservation	Yes		Strike-slip	Fracture zones, offset streams and fences

Plotting the Evidence (page 124)

Key Question: What do the locations of Earthquakes and volcanoes tell us about the location of the Earth's lithospheric plates?

Learning Goals:

(1) Plot the latitude and longitude for earthquake and volcano data

(2) examine patterns of such activity

(3) Infer location of the lithospheric plates based on evidence

Plotting the Evidence (page 124)

Directions:

1. In your assigned groups, process earthquake data by plotting the latitude (north/south) coordinates with the longitude (east/west) coordinates. Use a "**black dot**" for earthquake data on your overhead transparency.
2. Do the same for the volcano data, but instead use a "**red dot**" to indicate a specific data point.
3. Submit your transparency to the instructor.

Plotting the Evidence (124)

Earthquake Data (Black dot)

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- Group 5:
- Group 6:

Volcano Data (Red dot)

- Group 1: same
- Group 2: same
- Group 3: same
- Group 4: same
- Group 5: same
- Group 6: same

PLOTTING THE EVIDENCE

earthquake plotting data

GROUP 1 DATA	
4.0 S,	76.9 W
50.7 N,	175.3 E
6.7 N,	126.8 E
10.4 S,	118.6 E
34.5 N,	137.4 E
58.5 N,	153.4 W
71.7 N,	2.5 W
31.7 N,	51.0 E
62.9 S,	158.0 W
33.5 N,	22.9 E
53.6 S,	140.9 E
44.7 N,	9.5 E
36.4 N,	71.1 E
39.0 N,	74.9 E
29.6 S,	179.0 W
13.1 N,	125.9 E
34.3 N,	23.2 E
13.5 N,	125.6 E
40.3 N,	29.8 W
0.1 N,	66.9 E
49.7 S,	48.3 E
13.2 S,	30.1 E
17.1 N,	75.4 E
35.4 S,	92.1 E
31.2 N,	148.3 E

GROUP 2 DATA	
12.3 S,	167.2 E
44.5 N,	129.4 W
31.5 S,	76.5 E
21.1 S,	68.4 W
55.6 N,	162.4 E
17.9 N,	146.5 E
71.6 N,	1.5 W
24.5 N,	122.2 E
11.0 N,	57.5 E
52.7 N,	173.3 W
2.7 S,	125.7 E
36.9 N,	116.0 W
10.9 S,	165.7 E
81.9 N,	4.8 W
31.6 S,	178.1 W
54.3 N,	161.3 E
7.5 N,	77.5 W
12.6 S,	168.5 E
8.0 N,	126.4 E
57.2 N,	149.4 W
40.3 S,	65.1 E
10.3 S,	29.8 E
10.4 S,	89.4 E
3.3 N,	135.4 E
18.6 N,	122.1 E

GROUP 3 DATA	
21.7 S,	169.5 E
41.3 S,	88.8 W
4.3 S,	105.6 W
0.4 N,	67.2 E
36.3 N,	28.1 E
71.6 N,	2.5 W
51.6 N,	173.3 W
40.6 N,	124.5 W
13.0 S,	166.9 E
40.5 S,	176.8 E
20.3 S,	68.1 W
43.4 N,	126.7 W
32.1 S,	72.3 W
18.9 S,	172.6 W
51.5 N,	130.5 W
3.7 S,	11.9 W
36.3 N,	140.1 E
13.6 N,	56.6 E
56.6 S,	25.3 W
17.7 S,	174.7 W
1.2 N,	30.1 E
3.2 N,	92.4 E
28.4 N,	77.4 E
45.7 S,	175.4 E
5.7 N,	128.2 E

GROUP 4 DATA	
20.9 S,	179.0 W
51.4 N,	179.1 W
6.5 S,	124.7 E
57.0 N,	7.3 E
21.7 S,	170.4 E
9.0 S,	108.6 E
3.9 N,	125.8 E
40.3 N,	125.3 W
17.4 S,	113.8 W
38.7 S,	106.7 W
45.1 S,	90.5 E
44.5 S,	77.4 W
53.4 S,	111.4 W
18.2 S,	174.4 W
21.7 N,	142.9 E
49.0 S,	127.2 E
39.4 N,	39.4 E
5.3 S,	139.7 E
15.2 S,	70.6 W
31.8 S,	178.4 W
4.3 N,	34.1 E
13.4 N,	100.4 E
28.4 N,	60.1 E
49.7 S,	169.8 E
49.8 S,	145.3 E

GROUP 5 DATA	
46.6 N,	145.4 E
41.8 N,	143.9 E
10.3 N,	103.5 W
38.6 N,	40.6 E
39.4 N,	121.6 W
57.7 S,	15.3 W
49.6 N,	126.3 W
19.3 N,	155.0 W
37.5 N,	141.4 E
28.9 N,	177.4 W
5.0 S,	145.1 E
52.2 N,	176.2 W
49.3 N,	123.5 W
38.9 N,	142.5 E
27.1 N,	100.3 E
56.5 N,	25.2 W
30.0 N,	38.0 W
3.0 N,	27.1 W
18.2 S,	10.0 W
42.5 S,	14.5 W
12.4 N,	34.3 E
23.6 N,	98.3 E
29.1 N,	129.1 E
58.7 S,	167.9 E
57.3 S,	156.3 E

GROUP 6 DATA	
52.1 N,	175.8 E
38.7 N,	22.6 E
26.3 S,	27.3 E
34.3 N,	116.3 W
53.8 S,	141.5 E
50.1 S,	13.1 W
56.1 S,	11.3 W
59.1 S,	8.4 W
26.3 N,	115.6 W
57.2 S,	136.4 W
25.6 N,	142.5 E
7.8 N,	38.8 W
42.2 N,	90.5 E
43.7 N,	28.6 W
12.8 N,	87.3 W
57.9 S,	27.4 E
58.7 S,	3.2 E
64.3 S,	18.4 W
56.4 S,	34.3 W
51.7 S,	52.3 W
7.4 N,	30.4 E
28.7 N,	88.9 E
10.1 N,	143.7 E
62.8 S,	172.7 E
69.3 N,	13.3 W

PLOTTING THE EVIDENCE

volcano plotting data

GROUP 1 DATA

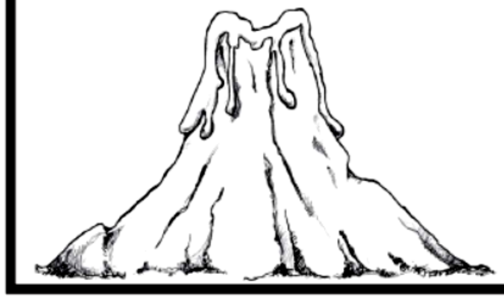
Popocatepetl, Mexico
19.0N, 98.6W
Mount Ranier, United States
47.0N,122.1W
San Francisco Peaks, United States
35.1N, 112.2W
Piton de la Fournaise,
Island of Reunion
21.2S, 55.7E
Sakura-Jima, Japan
31.6N, 130.7E
Fuego, Guatemala
14.5N, 90.9W
Soufriere Hills,
Montserrat, West Indies
16.7N, 62.2W
Tavurvur, Papua New Guinea
4.3S, 152.2E
Mount Baker, United States
49.1N, 122.2W
Etna, Sicily, Italy
37.7N, 15.0E

GROUP 2 DATA

Mount Baker, United States
49.2N, 122.0W
Sakurajima, Japan
32.1N, 133.3E
Arenal, Costa Rica
10.5N, 84.7W
Ulawun, New Britain, Papua,
New Guinea
5.1S, 151.3E
Kaba, Sumatra, Indonesia
3.5S, 102.6E
White Island, New Zealand
37.5S, 177.2E
Sheveluch, Kamchatka, Russia
56.7N, 161.3E
Mayon, Philippines
13.3N, 123.7E
Semeru, Java, Indonesia
8.1S, 112.9E
Lascar, Chile
23.6S, 67.7W

GROUP 3 DATA

Guagua Pichincha, Ecuador
0.2S, 78.6W
Krakatau, Indonesia
6.1S, 105.4E
Mount Cameroon, Cameroon
4.2N, 9.2E
San Cristobal, Nicaragua
12.7N, 87.0W
Shishaldin, United States
54.8N, 163.9W
Usu, Japan
42.5N, 140.8E
Mount Pelee, Martinique
15.1N, 61.3W
Pacaya, Guatemala
14.4N, 90.6W
Hekla, Iceland
63.9N, 19.7W
Kilauea, United States
19.5N, 155.3W



PLOTTING THE EVIDENCE

volcano plotting data

GROUP 4 DATA

Masaya, Nicaragua
12.0N, 86.2N
Colima, Mexico
19.5N, 103.6W
Taal, Philippines
14.1N, 120.9E
Ruapehu, New Zealand
39.3S, 175.6E
Unzen, Japan
33.2N, 133.1E
Mount Lewotobi, Indonesia
8.5S, 122.9E
Shishaldin, United States
54.8N, 163.9W
Lassen Peak, United States
40.1N, 122.1W
Terceira, Azores
38.7N, 27.3W
Surtsey, Iceland
63.1N, 19.4W

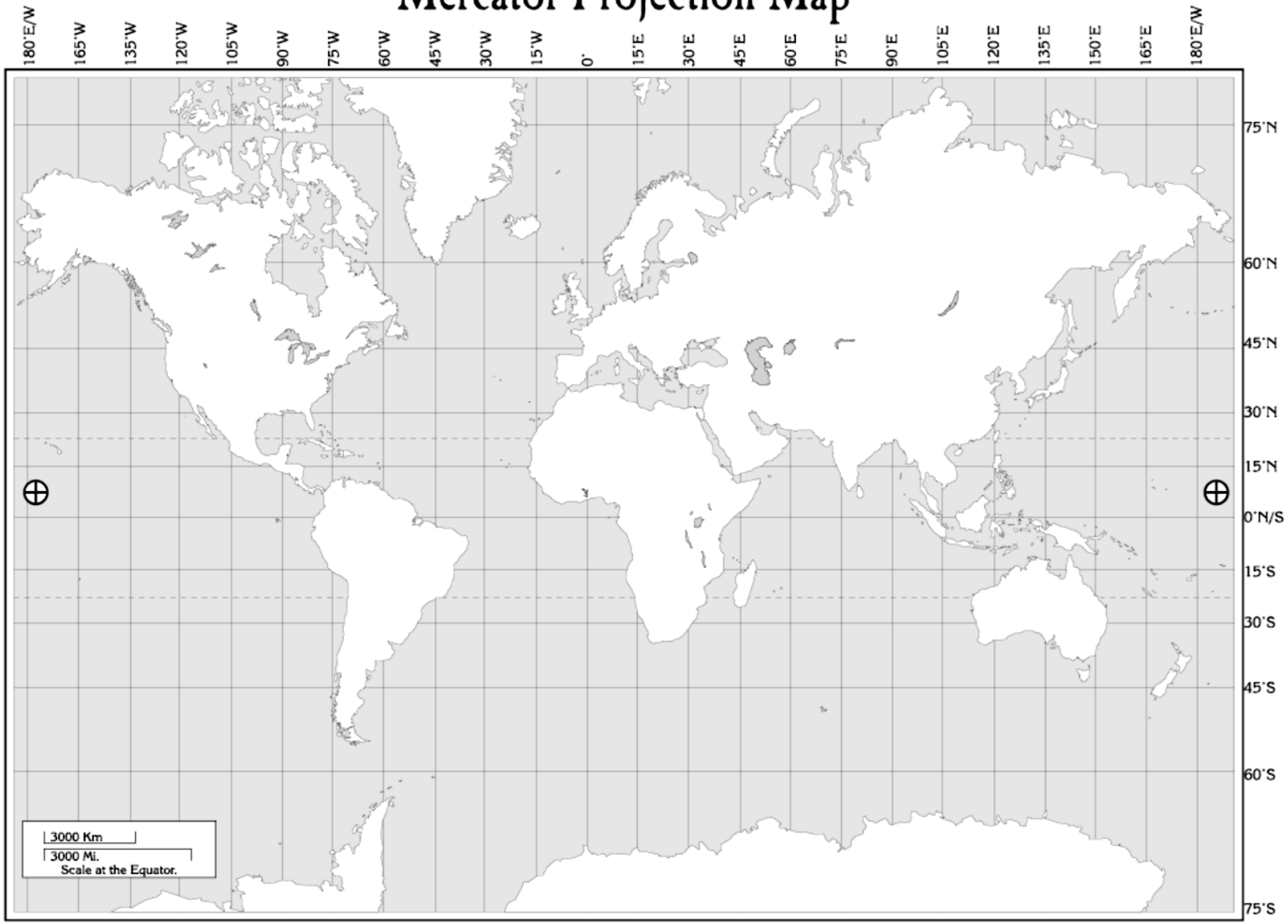
GROUP 5 DATA

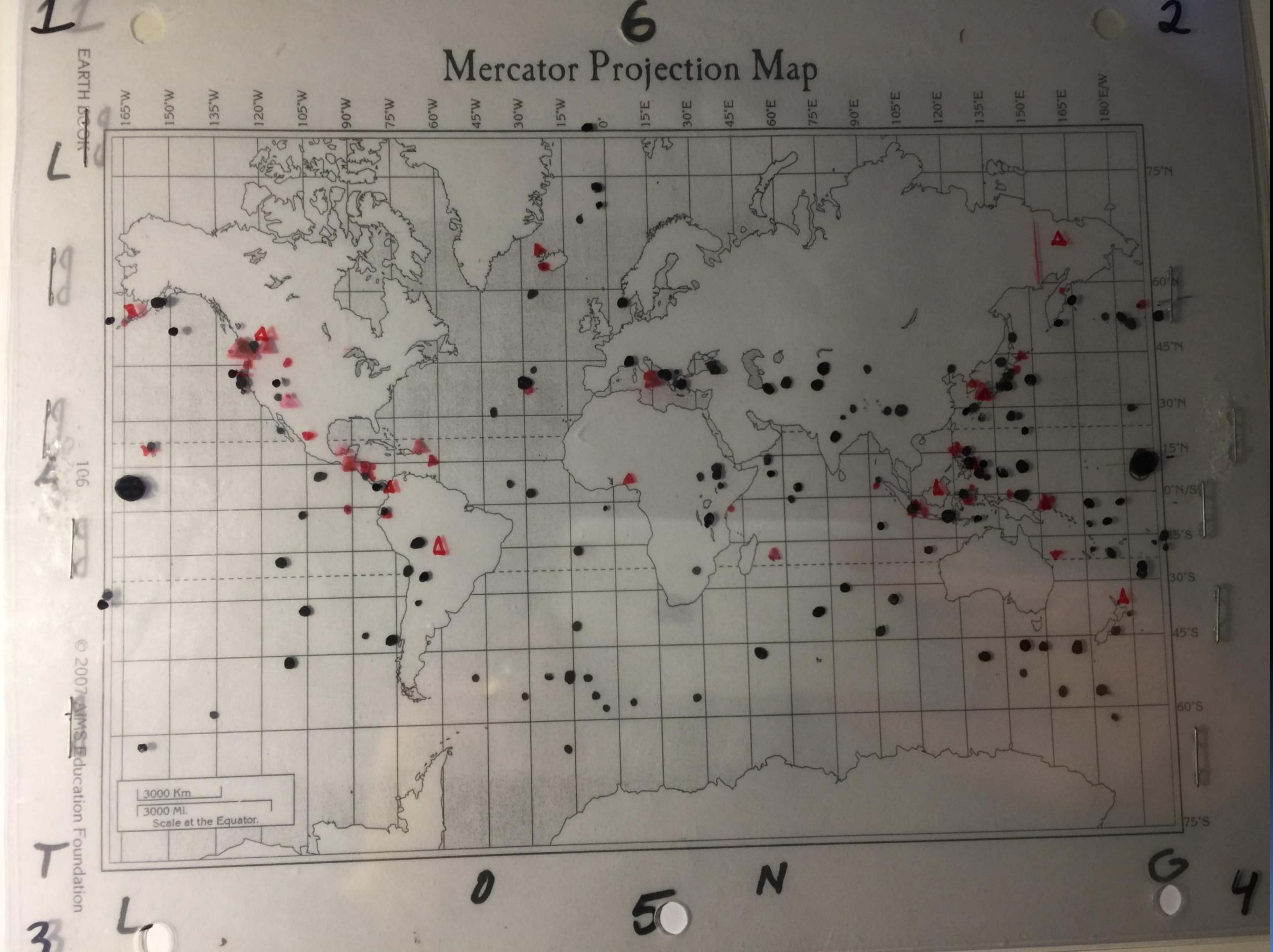
Merapi, Indonesia
7.54S, 110.44E
Manam, Papua New Guinea
4.1S, 145.0E
Cerro Azul, Galapagos Islands,
0.90S, 91.42W
Stromboli, Italy
38.8N, 15.2E
Iwate-san, Japan
39.85N, 141.00E
Papandayan, Java, Indonesia
7.32S, 107.73E
Mount St. Helens, United States
46.20N, 122.18W
Korovin, United States
52.38N, 174.15W
Yellowstone, United States
44.43N, 110.67W
Mount Peuet, Indonesia
4.925N, 96.33E

GROUP 6 DATA

Rincon de la Vieja, Costa Rica
10.2N, 85.5W
Mount Karangetang, Indonesia
2.8N, 125.5E
Mount Kiliamanjaro, Tanzania
3.2S, 37.4E
Rabaul, Papua New Guinea
4.3S, 152.2E
Kliuchevskoi, Russia
56.1N, 160.6E
La Madera, Nicaragua
11.4N, 85.5W
Mount Fujiyama, Japan
35.3N, 139.0E
Momotombo, Nicaragua
12.4N, 86.5W
Akutan, United States
54.1N, 166.0W
Mount Pinatubo, Philippines
15.2N,120.2E

Mercator Projection Map




Mercator Projection Map
165°W
150°W
135°W
120°W
105°W
90°W
75°W
60°W
45°W
30°W
15°W
0°
15°E
30°E
45°E
60°E
75°E
90°E
105°E
120°E
135°E
150°E
165°E
180°E/W
75°N
60°N
45°N
30°N
15°N
0°N/S
15°S
30°S
45°S
60°S
75°S
3000 Km
3000 Mi.
Scale at the Equator.
EARTH BOOK
106
© 2007 AIMS Education Foundation
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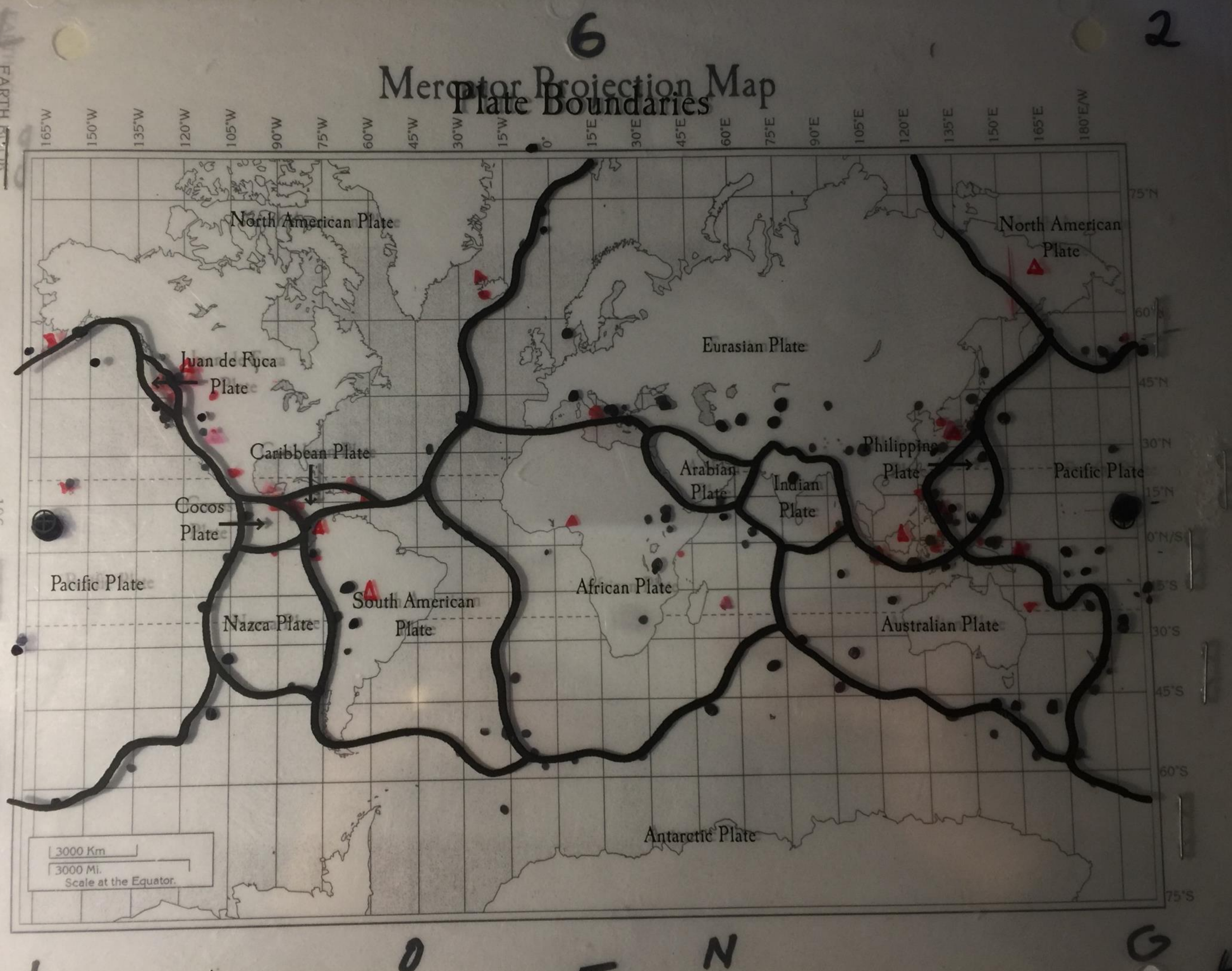

EARTH BOOK

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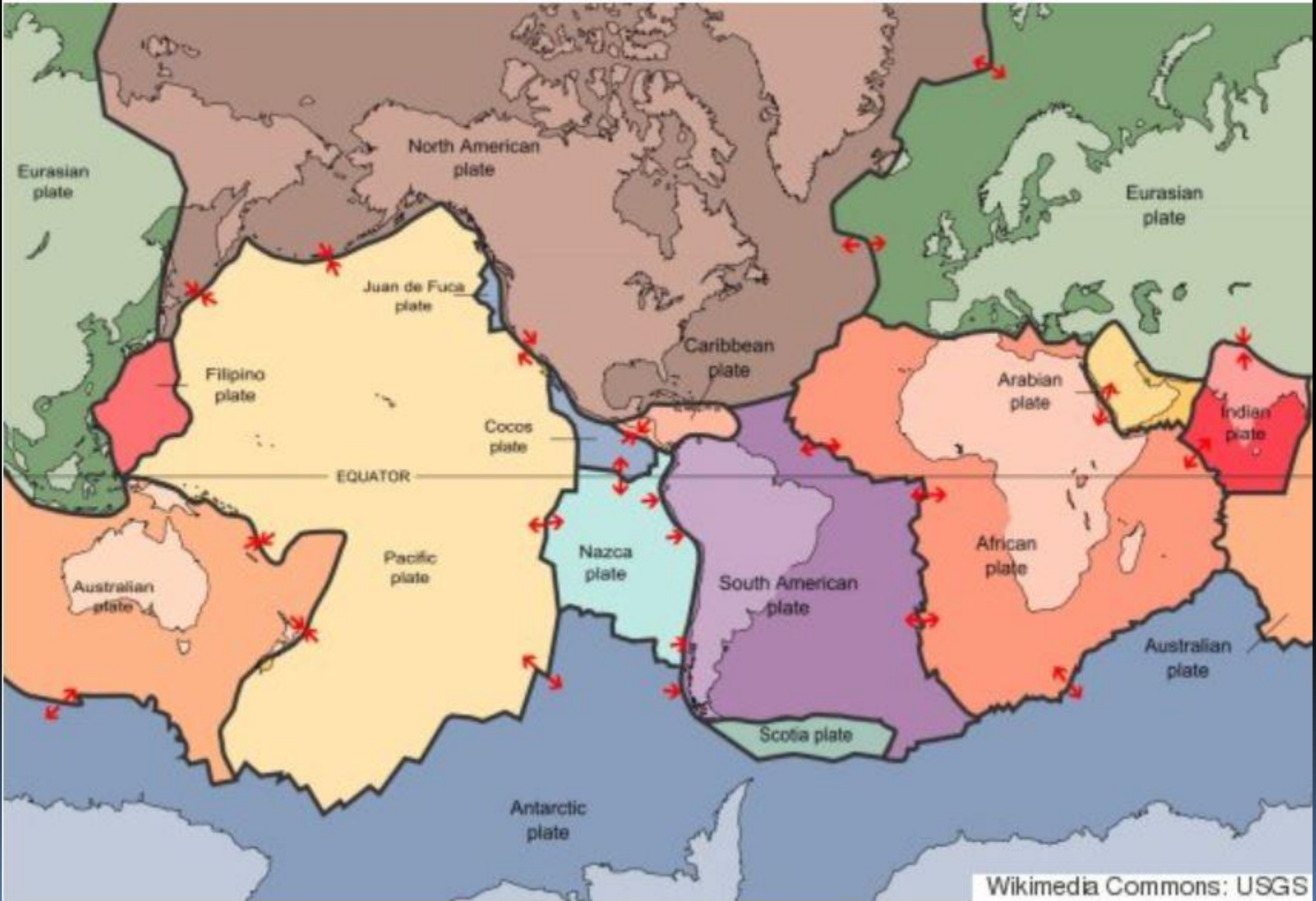
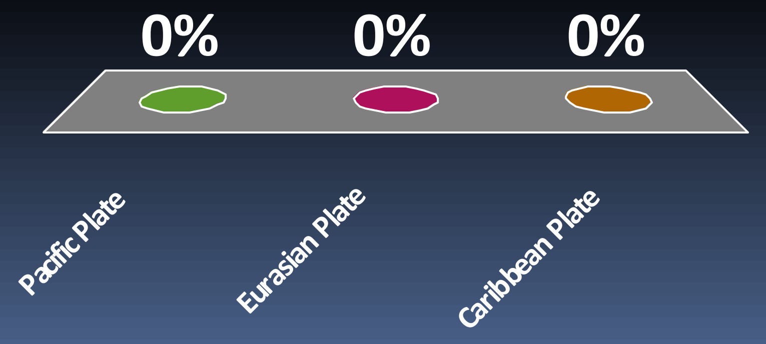

Eurasian plate
North American plate
Eurasian plate
Juan de Fuca plate
Caribbean plate
Filipino plate
Arabian plate
Indian plate
Cocos plate
EQUATOR
Nazca plate
Pacific plate
African plate
Australian plate
South American plate
Australian plate
Scotia plate
Antarctic plate
Wikimedia Commons: USGS

Which plate seemed to have the most earthquake and volcano activity?

A. Pacific Plate
B. Eurasian Plate
C. Caribbean Plate



Plotting the Evidence (page 124)

1. What evidence do you have that would explain why the Australian continent has very few earthquakes?
2. Compare the earthquake activity and volcanic activity of the west and east coasts of South America. Why do you think these continental margins are so different?
3. Do earthquakes and volcanoes only occur along the boundaries of plates?
4. There are mountain chains along the west coast of both and North and South America. Why do you think there are mountains at these locations?
5. Which plate seems to have the most earthquake and volcano activity?

Big Data, Small Devices

INVESTIGATION USING REAL-TIME GEOSPHERE DATA

TEACHER NOTES: CONVERGENT OR DIVERGENT?

Learning Goal	Students will explore the relationship between earthquake depth and tectonic plate boundaries.
Disciplinary Core Ideas	• Earth materials and systems • Plate tectonics and large-scale system interactions
Science and Engineering Practices	• Analyzing and interpreting data • Constructing explanations and designing solutions
Crosscutting Concepts	• Systems and system models • Structure and function
Background Information	The focus of an earthquake is the location where the earthquake originates. It is seldom on Earth's surface; usually, it is on a fault within the crust. The epicenter is the place on the surface directly above the focus. Earthquakes occur at different depths and are classified by focus-depth range as shallow (0–70 km), intermediate (70–300 km), or deep (> 300 km). The depth of an earthquake provides information about the type of plate boundary it is near. Deep earthquakes are more often associated with subduction zones and convergent boundaries, whereas shallow earthquakes are associated with divergent and transform boundaries.

DATA AND TECHNOLOGY

Online Sources	• U.S. Geological Survey (USGS) *Earthquake Hazards Program* website: *http://earthquake.usgs.gov/earthquakes/map* • QR Code: See Table 7.1 (p. 169).	USGS *Earthquake Hazards Program* website smartphone screenshot
App and Device Sources	 *Quakefeed* app Platform: iOS	
	 *EQInfo Global Earthquakes* app Platform: Android	

Source: U.S. Geological Survey *Earthquake Hazards Program. http://earthquake.usgs.gov/earthquakes/map.*

DATA AND TECHNOLOGY *(continued)*

Technology Notes	The USGS *Earthquake Hazards Program* website has a responsive design and is ideal for use on any device. The settings can be changed to view data for different magnitudes and periods of time. To collect enough data for the activity, students will need to change the settings to view data for earthquakes happening over a longer period of time.
About the Data	**Data Sampling:** A teacher might want to encourage students to identify an "even" sampling of earthquakes (marked in blue, red, or green); that is, to spread out their samples geographically; rather than clustering them. It might be helpful to specify that they should record earthquakes within a given distance (for example, an area running 1,600 km along a plate boundary). **Data Type:** Focal-depth data are the interval-ratio type and can be arithmetically summarized. The three focal-depth categories are the nominal data type, and so a bar graph could be used to compare them. **Data Issues:** The Richter scale is a measurement of earthquake strength, or magnitude, which is a special type of data for which a mean cannot be calculated (see Chapter 4); however, one can calculate the mean of the focal-depth measurements to use for comparison.

USING AND ADAPTING THE ACTIVITY

About the Activity	For this activity, students must understand the types of plate boundaries (divergent, convergent, transform) as they look for relationships between depth and boundary type. Teachers should reinforce knowledge of geologic features by stressing that ridges and rifts occur at divergent boundaries and trenches occur at convergent boundaries. Many of the events reported in the data use these terms.
Scaling Down	To simplify this activity, assign students work in groups to research a different type of plate boundary or even a specific boundary. Then, have students share their reports with the class. When assigning groups, consider that not as many events occur at divergent boundaries. You might want to assign fewer students to these areas.
Scaling Up	For added complexity, provide students with a map that shows the locations of plate boundaries but not their types. The USGS *Earthquake Hazards Program* website does not include plate-boundary information (although some apps do). Students can use the data they collect to ... the type of plate motion occurring at each

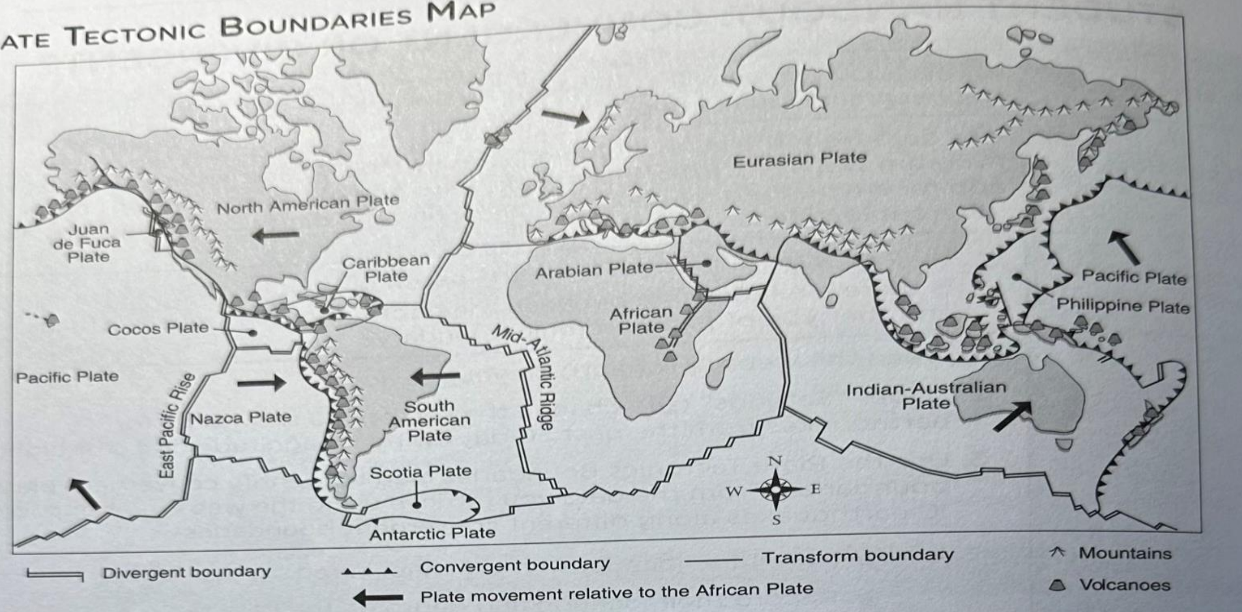
STUDENT HANDOUT: CONVERGENT OR DIVERGENT?

Activity Goal	In this activity, you will investigate whether there is a relationship between earthquake depth and the type of plate-tectonic boundary.
Technology Notes	Use data from the U.S. Geological Survey (USGS) *Earthquake Hazards Program* website (*http://earthquake.usgs.gov/earthquakes/map*) or an app recommended by your teacher to find the depth of earthquakes at different locations.
Orientation Questions	• How do earthquakes differ in the depth of their focus? • Is there a relationship between the depth of an earthquake's focus and the type of plate-tectonic boundary?
Directions	1. Open the website (or app) on your device. 2. Under "Settings" (⚙), change the settings to show data for earthquakes from the past 30 days with a magnitude of 4.5 or higher. 3. Use the Plate Tectonics Boundaries Map to identify convergent plate boundaries. From the data you retrieve using the website or app, pick 10 earthquakes along different convergent boundaries. a. Mark their locations on the map, in red. b. Record their location and depth on the data table. 4. Repeat the process for 10 earthquakes along divergent plate boundaries, marking them in blue. 5. Repeat again for 10 earthquakes along a transform boundary. You might have to adjust the magnitude settings to be able to see more events. Mark these in green. 6. Complete the Analysis Questions, Conclusions, and Reflection Question sections.

USGS Website

- https://earthquake.usgs.gov/earthquakes/map/

Plate Tectonic Boundaries Map



Data Table

Convergent Boundary		Divergent Boundary		Transform Boundary	
Location	Depth (______)	Location	Depth (______)	Location	Depth (______)
Mean Depth		Mean Depth		Mean Depth	

Analysis Questions

The focus of an earthquake is the location where the earthquake originates. An earthquake is categorized by the depth of its focus as shallow (0–70 km deep), intermediate (70–300 km) or deep (> 300 km).

1. What can the depth of an earthquake's focus tell you about the type of tectonic plate boundary it is most likely associated with?

2. At which type of plate boundary do the deepest earthquakes occur? Are most earthquakes at this boundary considered shallow, intermediate, or deep?

3. At which type of plate boundary do the shallowest earthquakes occur? Are most earthquakes at this boundary considered shallow, intermediate, or deep?

4. How do your data compare to data of your classmates?

Conclusions

Using what you know about the different type of tectonic plate boundaries, construct an explanation that discusses at which type of plate boundary the deepest earthquakes are most likely to occur and why.

Reflection Question

How does Earth's structure provide insight into where the deepest earthquakes are most likely to occur?