

Key Idea # 2

Standard # 4

Performance Indicator # 2.1

Key Idea # 1

Standard # 1

Scientific Inquiry

Key Idea # 1

Standard # 2

Information Systems

Key Idea # 1

Standard # 7

Connections

Activity Title: Earthquake Patterns & Plate Boundaries

Anticipated Lesson Length: 3-4 periods

Topic Name: Dynamic Crust

Major Understanding # 2.1I; STD 1-1 Inquiry; STD 2-1; STD 7-1

Major Understanding Statement:

The lithosphere consists of separate plates that ride on the more fluid asthenosphere and move slowly in relationship to each other, creating convergent, divergent, and transform plate boundaries. These motions indicate Earth is a dynamic geologic system.

- These plate boundaries are the sites of most earthquakes, volcanoes, and young mountain ranges.

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing creative process.

Information technology is used to retrieve, process, and communicate information as a tool to enhance learning. For example:

- Use library or electronic references to obtain information to support a laboratory conclusion.

The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to ... inquiry into phenomena.

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Assessing Prior Knowledge-

What causes earthquakes and volcanoes? What regions of the United States are most likely to experience these geologic hazards?

Motivation-

Show a video or film clip on earthquakes. Discuss where recent earthquakes and volcanoes have occurred. Why are some parts of the world more likely to experience earthquakes and volcanoes than others? How do earthquake patterns support the theory of plate tectonics? Can we predict earthquakes? Students will use a computer database of earthquake and volcano data to analyze the relationship between earthquakes, volcanoes, and other tectonic features.

Development of Understanding-

This activity is based on using the ***Seismic/Eruption Program***, which can be downloaded for free from the author's (Alan Jones) web site listed in the references. The activity "**Earthquake Patterns and Plate Boundaries**" can be modified for use with other sources of earthquake and volcano data as an alternative teaching strategy.

This activity is ideally suited for use in a computer lab where each student or pair of students has their own station. Alternatively, the program may be effectively used as a demonstration of earthquake patterns. The program is a database with information on thousands of earthquakes and hundreds of volcanoes. Through use of various screens, it shows several views of the world and actively plots earthquake data from 1960 to the present. The patterns of crustal activity are apparent in full color as the earthquakes are plotted on the map. The program shows earthquake epicenters, magnitude, and depth. Magnitude is indicated by the size of the dot. Depth is indicated by color. The shallowest earthquakes are red, and the deepest are green or yellow. The program also includes volcanic eruptions.

Explain that students will use the ***Seismic/Eruption Program*** to make observations and analyze earthquake patterns. In addition to patterns, they should also determine if there are any depth and magnitude patterns that relate to type of plate boundary. Hand out the lab "**Earthquake Patterns and Plate Boundaries.**"

Demonstrate how to open the program and use the tool bars. First, students should be given time to explore the program. They should first look at the World View and allow the program to run for a few minutes. In a short time, they should observe a worldwide pattern of earthquakes (that mirrors the plate boundaries). Have them follow directions in Part A of the lab.

After they are comfortable with the program, they should begin Part B, in which they will first classify the type of plate boundaries in different parts of the world. They should use the *Tectonic Plates Map* in their *Earth Science Reference Tables* and record their observations in the data table provided. Using the ***Seismic/Eruption Program***, they should observe each region, and analyze the magnitude and depth of earthquakes. In order to best observe the depth of earthquakes, they should change the size of the dots to small dots. They will have to return to large dots to evaluate the magnitudes of earthquakes.

Students should conclude that earthquakes, volcanoes, ocean trenches, mid-ocean ridges, and mountain ranges occur in the same locations. They should also notice that different features occur at different kinds of plate boundaries. Students should observe that divergent boundaries occur where there are mid-ocean ridges, and tend to have lower magnitude earthquakes. Convergent boundaries have volcanic mountains, trenches, and the strongest earthquakes. They should also be able to discover that subduction zones have progressively deeper earthquakes as the subducting plate sinks deeper under the opposing plate. An excellent area to demonstrate this is New Zealand's complex plate boundaries. The west coast of South America also shows this relationship, but it is more difficult to discern the pattern.

Checking for Understanding-

While the students are using the program, the teacher should monitor progress and check for understanding. Use the questions from Part A to check understanding of use of the program as well as earthquake patterns.

Further Development & Understanding-

Students could monitor earthquake activity in the world by using various Internet sites. They could plot the locations and magnitudes of these earthquakes on a large world map in class.

Students could analyze the relative earthquake risk in different parts of the United States. For example, a comparison of the eastern part of the United States with the West Coast or New York with California would be pertinent to students' lives. They could use the Seismic/Eruption program to evaluate the number and size of earthquakes in the different regions. Current data could be obtained from Internet sources.

Assessment-

Students should be required to hand in the completed laboratory report. Use the **Inquiry Lab Scoring Rubric** (from Appendix C) to evaluate student achievement.

References-

Jones, Alan Seismic/Eruption Program

Seismic/Eruption “Freeware”

This is an extensive database on (IBM PC format) of earthquakes and volcanoes throughout the world. It is an interactive tool in which earthquakes and volcanoes can be displayed on world and regional maps. It is available for free and can be downloaded from either of the sites listed below.

IRIS Software Exchange Library

<ftp://dmc.iris.washington.edu/pub/programs/sel/ibmpc>

Alan Jones Home Page (author of the program)

<http://www.geol.binghamton.edu/faculty/jones>

Osmun, R., Vorwald, B., and S. Wegner. (1995). “Patterns of Crustal Activity” & “Plate Boundaries” labs in *Explorations in Earth Science*. Albany: United Publishing Company.

Useful Web Sites for Earthquakes and Plate Tectonics

- **The Dynamic Planet** (USGS On-line publication)
<http://pubs.usgs.gov/publications/text/dynamic.html>
- **USGS Earthquake FAQs** (Frequently Asked Questions)
<http://geology.er.usgs.gov/eastern/earthquakes/eqfaq.html>
- **Earthquakes and New York State**
<http://nceer.eng.buffalo.edu/faqs/index.html>
- **Recent Earthquakes** (global)
<http://quake.wr.usgs.gov/recent/eqs/>
- **Virtual Earthquake Lab** (Cal. State University Electronic Desktop Project)
<http://vearthquake.calstatela.edu/>
- **Bob's Earthquake Page** (history, richter scale, prediction, damage, etc.)
www.nittlion.com/
- **SCEC Earthquake Display Outreach Program**
<http://quake.crustal.ucsb.edu/>
- **AITLC Guide to Earthquakes**
<http://tlc.ai.org/>
- **Earthquake Hazards and Preparedness** (USGS)
<http://quake.wr.usgs.gov/hazprep/index.html>
- **Earthquake Information** (Caltech Seismo Lab: seismograms, maps)
<http://www.gps.caltech.edu/>
- **EQNET: Earthquakes and the Federal Government**
<http://www.eqnet.org/>
- **Seismology Resources for Teachers** (Larry Braile)
http://www.geo.purdue.edu/seismology_resources.html

Name _____

Date _____

Earthquake Patterns Lab

Purpose: To investigate worldwide patterns of earthquakes and determine the relationship of these patterns to types of plate boundaries.

Problem:

- 1) Describe the patterns of earthquake locations around the world. Where do most earthquakes occur?
- 2) Describe the patterns of earthquakes at the different types of plate boundaries. Is there a relationship between magnitude and the depth of the earthquakes and the type of plate boundary?

Vocabulary:

Epicenter

Magnitude

Depth of focus

Convergent Plate Boundary

Divergent Plate Boundary

Transform Plate Boundary

“Ring of Fire”

mid-ocean ridge

trench

Method:

Your task is to observe the earthquake patterns, both the location of the epicenter and the depth of the focus and determine if there are patterns that relate to type of plate boundary. Use the Seismic/Eruption Program to make observations and analyze earthquake patterns. The program is a database containing thousands of earthquakes that have occurred since 1960. Several regions of the world can be studied in map view and some in 3-D views. The program shows earthquake epicenters, magnitude, and depth. Magnitude is indicated by the size of the dot. Depth is indicated by color. The shallowest earthquakes are red, and the deepest are green or yellow. Refer to the legend when you access the program. The program also includes volcanic eruptions.

Procedure:

Part A. Learning How to Use the Seismic/Eruption Program

1. Start the program by clicking on its icon. Select **World View** and observe the earthquakes for a few minutes. (You can speed up the program by changing the speed toolbar to "fast speed.") "What do you notice? Look at the legend that shows what the color and size of the dots mean. Look at the world map and click on various regions of the world. You can return to the main screen by pressing the Restart icon.
2. You can manipulate many of the variables as you conduct your research. Play around with the toolbars and experiment with different settings. Take some time to change some of the settings, such as large dots to small dots; changing the dates, and changing the magnitude range (EQ Cutoff). For example, to study where the largest earthquakes have occurred, you can change the setting of the earthquake cutoff (EQ Cutoff) to 7. You can look at several different views of the world or regions. One of the most helpful features is the setting under map options where you can make your own map of an area.
3. After experimenting with the toolbars and settings check your understanding by answering the following questions that follow. Select **Atlantic** under the view menu. You will see a view of the Atlantic Ocean with earthquakes occurring over a set range of time.

Part A: Questions

1. What is the range of dates of earthquakes shown in this view?
2. How can you tell the depth of an earthquake?
3. How deep is the deepest earthquake that has occurred along the west coast of South America? (Tip: You should change the dots to white dots).
4. How can you tell the size (magnitude) of earthquakes?
5. What is the average size of an earthquake in the middle of the Atlantic? (Change the dots back to “keep large dots”).
6. How do earthquake locations compare to plate boundaries?
7. How do volcano locations compare to earthquake locations and plate boundaries?
8. Where do most of the active volcanoes occur? (You should go to the World View to answer this question).

Part B: Plate Boundary Observations

1. Use your *Earth Science Reference Table* to identify the different types of plate boundaries at the locations indicated. Record this information in the data table. Record other features that are associated with each plate boundary such as trenches, mountains, volcanoes, mid-ocean ridges, etc.
2. After you identify the plate boundaries, study the magnitudes and depths (shallow, medium or deep) of the earthquakes at these locations. Record your observations in the table.

Location	Type of Boundary	Type of Crust Involved	Names of Plates	Earthquake Depths	Earthquake Magnitudes	Other features
West Coast of South America	Convergent	Ocean/Continental	Pacific/South American			
Mid Atlantic Ocean						
Aleutian Arc						
New Zealand						
West Coast US						
Japan						
Hawaii						
India						

Analysis:

Relate your observations to the types of plate boundaries. Study your data at the different locations and evaluate if there are patterns of depth and magnitude at each type of boundary.

Convergent Boundaries:

Continental/Continental

Continental/Ocean

Ocean/Ocean

Divergent Boundary

Transform Boundary

Conclusions:

Answer the problem questions and summarize your findings about plate boundaries.

Evaluation:

What did you learn from this activity that you did not know before? What challenges did you encounter in doing this activity? How could you improve upon your research? What parts did you find difficult? What parts did you enjoy? How did this type of activity help you learn about plate boundaries and earthquakes? What recommendations do you have for improving this lab? Would you recommend this lab for future students? Why?