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Earthquakes in Pennsylvania?

Margin Notes

When you hear about earthquakes, you usually think of California, but did you know that earthquakes can occur in Pennsylvania?

On January 16, 1994, an earthquake measuring 4.6 on the Richter scale hit near Reading, a suburb of Philadelphia. Tremors were felt as far away as Philadelphia, New York, and Baltimore. The earthquake damaged the foundations and walls of several homes and formed cracks and a sinkhole about 8 feet deep and 25 feet wide in several roads¹.

Most earthquakes occur near **plate boundaries**, but it is possible for earthquakes to occur at faults within a plate. **Faults** are breaks in the earth's crust where plates can move. An area where earthquakes occur within a plate is called an **intraplate seismic zone**.

The closest plate boundary is the Mid-Atlantic Ridge, which is about 2,000 miles east of Pennsylvania. However, 200 million years ago when Pangaea was separating to form the Atlantic Ocean, the northeastern coast of America was at a plate boundary. As a result, many faults formed in the region.

There are two seismically active zones in Pennsylvania, one in Lancaster and another in the northwestern part of the state near Lake Erie. The largest earthquake to have occurred in the Lancaster zone measured 4.6 on the Richter scale.

Although there are significantly fewer earthquakes in intraplate areas, they can cause considerable damage, particularly in the eastern United States. When a magnitude 4 or 5 earthquake strikes Pennsylvania, the energy from the earthquake is transferred much quicker and farther than in the western United States because many of the rocks in Pennsylvania are old, crystalline, and fractured. Therefore, an earthquake that causes little damage in California may cause considerably more damage in the eastern United States².

¹ Record Earthquake Jars Pennsylvania; Damage is Minimal. NY Times. Jan. 16, 1994.

² Earthquakes in Pennsylvania? The Lehigh Earth Observatory.

<http://www.leo.lehigh.edu/projects/seismic/pennquakes.html>

Record Earthquake Jars Pennsylvania; Damage Is Minimal

READING, Pa., Jan. 16 (AP) — Southeastern Pennsylvania experienced its largest earthquake on record this weekend, but it caused little damage and was light by the standard of geophysicists.

The record was set by one of two tremors that hit the area on Saturday night. The first quake measured 4.0 on the Richter scale of ground motion; the second measured 4.6, according to the National Earthquake Information Center in Golden, Colo. The epicenters were near Wyomissing Hills, just west of Reading.

In California, 4.6-magnitude tremors occur every couple of weeks, said Bruce Presgrave, a geophysicist at the center. But such quakes are highly unusual for this state.

"Pennsylvania," unfortunately, "has had more than its fair share of natural disasters and challenges — from floods and tornadoes to blizzards — and now we have to add earthquakes," Lieut. Gov. Mark Singel said today as he surveyed damage.

Mr. Singel, who said he felt after-shocks as he toured the area, said he found only minor damage. No injuries were reported.

Dozens of homes received damage to foundations and walls, Mr. Singel said. The tremors also opened several cracks in roads and a sinkhole about 8 feet deep and 25 feet wide.

The damage was concentrated in a 3-square-mile area in Wyomissing Hills.

The Saturday tremors were also felt in the Philadelphia, New York and Baltimore areas. Afterward, police departments in Philadelphia suburbs, about 60 miles away, said they were deluged with telephone calls.

"The room just shook," said Officer Fred Brossman. "It was hard to explain. I've never experienced one before. It wasn't that extensive, but it shook really good. I was watching and my soda can started trembling."

The Problem

The newly-elected Mayor of Reading, PA is very concerned after reading a *NY Times* article about the earthquake that hit Reading in 1994. The mayor was a philosophy major in college and knows absolutely nothing about earthquakes or what to do if an earthquake hit again. He thought that earthquakes only occur in California.

He frantically calls your office at the Seismic Activity Division of the United States Geological Survey to ask for some help. He wants to hire you to tell him more about earthquakes in Pennsylvania and develop an earthquake readiness plan. He's worried about the effects that earthquakes could have on the city, as they can be more destructive than those in California. Since they do not occur that often, he's unsure if it's worth spending the money to make the city "earthquake-proof", but he's also afraid of the consequences if he does nothing.

The Assignment

Your task is to answer the following questions from the Mayor and present an earthquake readiness plan to the City Council in the form of a multimedia product.

Section 1: Information about Earthquakes

- What causes earthquakes?
- Where do earthquakes usually occur? Why?
 - Why do earthquakes occur in Pennsylvania?
 - Why can they be more dangerous than earthquakes in the western part of the United States?
- How do scientists determine the location of an earthquake?
- How do we measure the strength of an earthquake?
- Is it possible to predict when earthquakes may occur? If so, how?

Section 2: Earthquakes' Effects on People

- What consequences would an earthquake have on people?
- If we are unsure when the next major earthquake will hit Reading, is it worth having an earthquake readiness plan and spending money to make buildings "earthquake-proof"?

Section 3: Reading's Earthquake Preparedness and Response Plan

- How can Reading construct or reinforce their buildings to make them "earthquake-proof"?
- What should people do to prepare for an earthquake?
- How can people ensure their safety during an earthquake?

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Final Product

As the City Council's advisors, they have asked you to use your group's creativity to present your proposal in the form of a video presentation. It is essential that your group uses the evidence found from your research to support all aspects of your presentation.

In the presentation, you should include the following:

- **Information about why earthquakes occur in Pennsylvania**
 - Suggestions: Use maps, diagrams, or props
- **Potential consequences of earthquakes on the city**
 - Suggestions: Include actual footage or pictures of earthquake damage OR construct a scene showing the aftermath of an earthquake
- **Analysis of whether the City Council should spend money to make the city "earthquake-proof"**
 - Suggestions: You may want to have a discussion that shows both sides of the issue and use evidence to support your group's view.
- **Earthquake-readiness plan**
 - Suggestions: Take us on a tour of your house and show places that could be potential sources of injury and various ways that you could make your house "earthquake-proof".

Together with your group's final product, you will include your map showing the locations of earthquakes and volcanoes, bibliography, peer evaluations, research logs, and any other material that you may have used to create your final product.

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Research Log

Each person will be documenting his or her research on the datasheets. You will hand in your individual log sheets together with your group's final product. Everything should be written in **YOUR OWN WORDS**. Do not include text copied from the internet. If you are caught cheating, your entire group will receive a zero.

Grading

The final product will be given a group grade, and will be assessed based on the following criteria:

- Accuracy and thoroughness of research sheets
- Strength of argument for or against making the city "earthquake-proof"
- Feasibility of earthquake readiness plan
- Organization
- Creativity
- Effective use of props
- Ability to work effectively as a group
- Proper citation of sources

However, you will receive individual grades for the research logs and your contributions to the group. Your participation will be evaluated based on the teacher and the anonymous evaluations by your fellow group members. We are doing this to ensure that everyone is participating equally.

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Final Product³

As the City Council's advisors, decide whether the City Council should spend money to make the city "earthquake-proof" and develop an earthquake readiness plan. Use evidence to support your recommendation. You should provide a short summary of why earthquakes occur, outline the city's options, and provide your proposal for an earthquake readiness plan. Each student must type their own recommendation based on the group's research.

³ Teacher's Note: Use this alternate product in place of the multimedia presentation if time is short.

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Sources for Information

<http://courseweb.gse.upenn.edu/~abrahaml/hth/>

Earth Science Bulkpack: p. 132-137, 144-148, 154-171

Earthquakes in Pennsylvania

Earthquakes in Pennsylvania? - <http://www.leo.lehigh.edu/projects/seismic/pennquakes.html>
List of Earthquakes in Pennsylvania by Region - <http://muweb.millersville.edu/~esci/geo/quake.html>
Local Earthquake History and Information - <http://muweb.millersville.edu/~esci/geo/paquakes.html>
NY Times: Record Earthquake Jars Pennsylvania -
<http://www.leo.lehigh.edu/projects/seismic/graphics/reading.jpeg>

Faults, Earthquakes

Cool Earthquake Facts - <http://earthquake.usgs.gov/4kids/facts.html>
Earthquakes FAQ - <http://earthquake.usgs.gov/faq/>
Faults and Earthquakes - <http://www.uwgb.edu/dutchs/2020vhds/quakes.htm>
Photos of Earthquakes and Faults - <http://earthquake.usgs.gov/bytopic/photos.html>
Types of Seismic Waves - <http://www.exploratorium.edu/faultline/earthquakescience/pswaves.html>

Predicting and Measuring Earthquakes

How Are Earthquake Magnitudes Measured? - <http://www.geo.mtu.edu/UPSeis/intensity.html>
Monitoring Earthquakes in the United States - http://geohazards.cr.usgs.gov/factsheets/html_files/eq1/fini.html
Quake Forecasting- An Emerging Capability - <http://quake.wr.usgs.gov/prepare/factsheets/QuakeForecasts/>
USGS: The Severity of an Earthquake - <http://pubs.usgs.gov/gip/earthq4/severitygip.html>

Mapping

National Earthquake Information Center: Near Real Time Earthquake List -
<http://www.neic.cr.usgs.gov/neis/bulletin/>
Current Volcanic Eruptions - http://volcano.und.nodak.edu/vwdocs/current_volcs/current.html

Effects on People

Effects of Earthquakes - <http://earthquake.usgs.gov/faq/effects.html>
Reducing Earthquake Losses Throughout the United States -
<http://quake.wr.usgs.gov/prepare/factsheets/BayArea/>

Earthquake Safety

American Red Cross - <http://www.redcross.org/services/disaster/keepsafe/readyearth.html>
CNN - Quake engineering Building for future on lessons from past -
<http://www.cnn.com/US/9908/19/quake.engineering/>
Earthquake Drills Do's And Don'ts - <http://www.sfgate.com/cgi-bin/article.cgi?file=/earthquakes/archive/quakedrill.dtl>
Exploring Earth: Learning More About Earthquake Safety (Links) -
http://earthsci.terc.edu/content/data_centers/es1006.cfm?chapter_no=datacenter
SFGate.com: Earthquake Survival and Preparedness Resource - <http://www.sfgate.com/earthquakes/>

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The Assignment: Part 1

Your first task is to answer some of the Mayor's questions about earthquakes:

- What causes earthquakes?
- Why do earthquakes occur in Pennsylvania?
- How do scientists determine the location of an earthquake?
- How do we measure the strength of an earthquake?
- Is it possible for scientists to predict when earthquakes may occur? If so, how?

The class will be divided into five groups to tackle each topic. Your group will research the answers to your assigned question and record your data on the given research log sheet.

Afterwards, you will use your research to develop 3-5 bullet-points that summarize the answer to your question. Write these bullet points on chart paper and post them around the classroom. Your group will then present your findings from the class.

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Group 1: What causes earthquakes?

Your group's task is to determine what events cause earthquakes to occur. In addition to your own research, you should to find out the answers to the following questions:

- What are earthquakes?
- What causes them?
- What are strike-slip faults? Describe the plate movement at strike-slip faults.
- What are seismic waves?
 - Where do they originate?
 - Are there different types of seismic waves? If so, explain.

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Group 2: Why do earthquakes occur in Pennsylvania?

Your group's task is to determine why earthquakes occur in Pennsylvania. In addition to your own research, you should to find out the answers to the following questions:

- How can faults in Pennsylvania form 2000 miles away from the nearest plate boundary, the Mid-Atlantic Ridge?
- Where are the most seismically-active areas in Pennsylvania?
- How severe are the earthquakes in Pennsylvania?
- Why can they be more dangerous than earthquakes in the western part of the United States?
- Outside of Pennsylvania, where do earthquakes occur most often? Why?

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Group 3: How do scientists determine the location of an earthquake?

Your group's task is to find out how scientists determine the location of an earthquake. In addition to your own research, you should find out the answers to the following questions:

- How do scientists detect earthquakes?
- How do scientists calculate their distance away from the location of an earthquake?
- What is the name of the location of an earthquake?
 - Is this location different from where seismic waves originate?

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Group 4: How do we measure the strength of an earthquake?

Your group's task is to determine how scientists measure the strength of an earthquake. In addition to your own research, you should find out the answers to the following questions:

- What is magnitude?
- How do scientists detect earthquakes?
- Do scientists use a scale to determine whether an earthquake is weak or strong?

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Group 5: Is it possible for scientists to predict when earthquakes may occur?

Your group's task is to determine whether it is possible for scientists to predict when earthquakes may occur. In addition to your own research, you should to find out the answers to the following questions:

- What events usually happen before an earthquake?
- What methods do scientists use to detect plate movement?

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Mapping Earthquakes and Volcanoes⁴

1. Use the USGS Earthquake Bulletin (http://gldss7.cr.usgs.gov/neis/bulletin/bulletin_list.html) to see all of the earthquakes that have occurred over the last few days with a magnitude larger than 2.5 on the Richter Scale. In the second two columns, you will see the latitude and longitude coordinates for the epicenter of the earthquake.
2. You are to choose 10 earthquakes from various locations around the world. Write down in the chart below which earthquakes you are plotting.
3. Use the latitude and longitude coordinates to plot a colored star on your world map that represents the epicenter of the earthquake.

Location	Latitude	Longitude

⁴ Teacher's Note: You can also make this a class activity by plotting the earthquakes on a class map.

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Questions

1. Is there a recognizable pattern to where earthquakes seem to occur? If so, describe the locations where earthquakes are most likely to occur.

a. Plot Reading, PA (40°N , 76°W) on the map. Based on its location, what is Reading's risk for having an earthquake?

Compare your map with the map located at <http://geology.er.usgs.gov/eastern/plates.html>.

2. Do you see any relationship between the map you created and the map above showing tectonic plates? If so, explain.

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How Do Volcanoes Work into the Picture?

Choose 10 active volcanoes to plot using the Current Eruptions from Volcano World website (http://volcano.und.nodak.edu/vwdocs/current_volcs/current.html), which shows recent volcanic activity.

Location	Latitude	Longitude

Plot the locations of the active volcanoes on the map where you plotted your earthquakes. Make sure that you use a color or symbol that is DIFFERENT from the one you used to plot the earthquakes.

Questions

1. From your map, can you determine whether volcanoes have anything to do with the plate boundaries?

2. Do earthquakes and volcanoes often appear in the same locations? Support your answer with an example from the map.

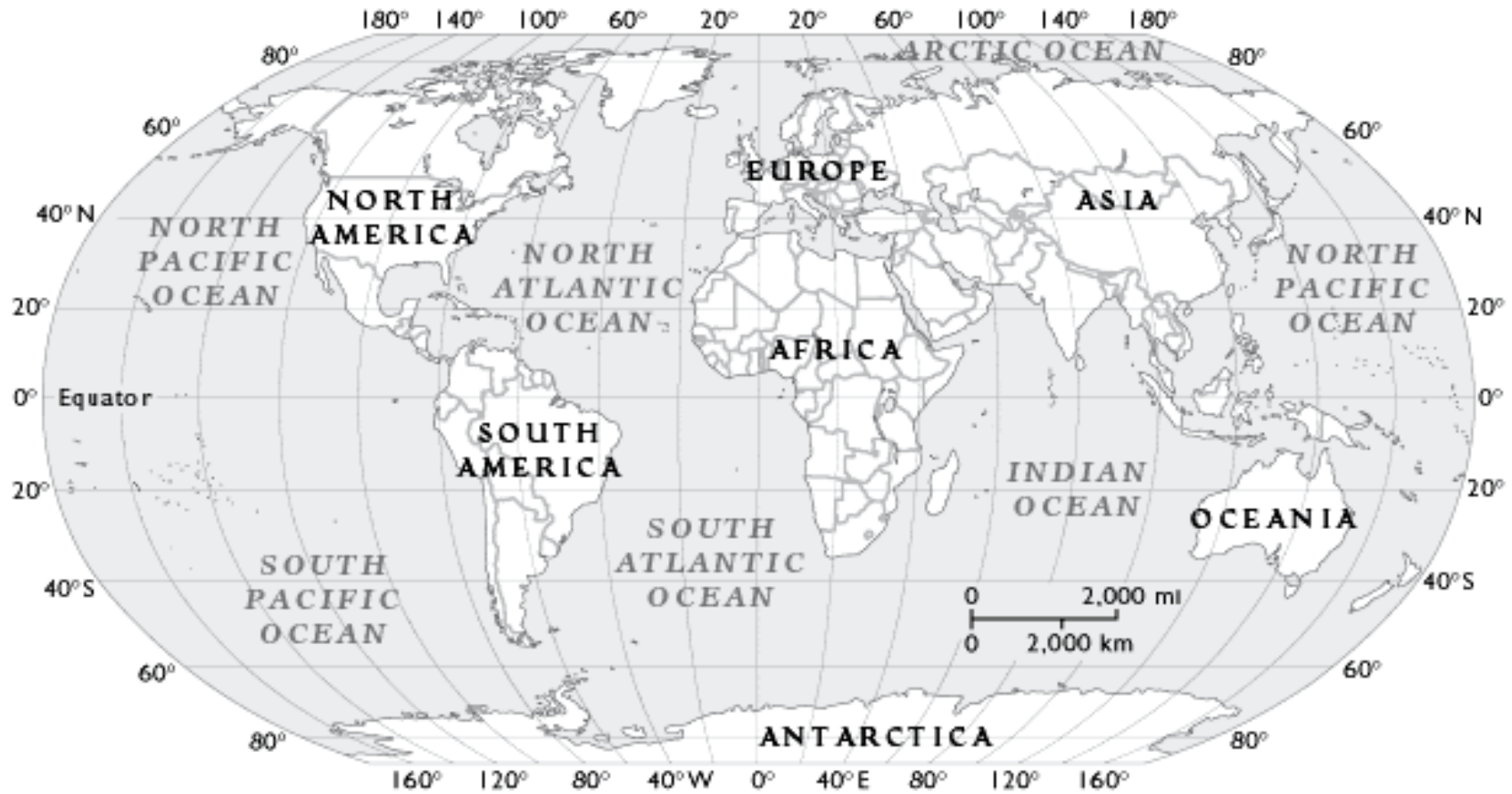
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THE WORLD



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Section 3: Earthquake Preparedness Plan

The Mayor of Reading would like you to prepare an earthquake preparedness plan in the event that the City Council votes to spend money to make Reading “earthquake-proof”. Use the backpack/textbook and internet resources on the HTH website to help you find the information

1. How can Reading construct or reinforce their buildings to make them “earthquake-proof”?

2. When deciding which buildings the city will make “earthquake-proof”, which buildings should receive priority?

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3. What should people do to prepare for an earthquake?

4. How can people ensure their safety during an earthquake?

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Section 4: Bibliography

Record the sources that you used for this project using the MLA format. The style guide is listed on the HTH Earth Science Website.