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Mapping Earthquakes and Volcanoes

Geologic Connection or "Puzzling" Coincidence?

Introduction

Mother Nature's most spectacular phenomena, earthquakes, volcanic eruptions and their associated effects, make headline news whenever and wherever they occur. Are these two singular events related? Are earthquakes and erupting volcanoes more likely to occur in certain areas of the world than in others? Find answers to these important questions as you map the locations of such events around the world.

Concepts

- Map plotting—latitude/longitude
- Theory of Plate Tectonics

Background

For centuries, earthquakes and volcanoes have both fascinated and frightened. In ancient times, Poseidon, the "god of the sea" of Greek mythology was believed to possess the power of "earth-shaker" and Vulcan, the Roman god of fire and the forge, was thought to be "busy working" when volcanic eruptions occurred. Seismologists and volcanologists, those who study earthquakes and volcanoes, respectively, have provided us with more credible scientific explanations for these awesome displays of Nature's power. Unfortunately, however, our ability to predict when and where they will occur is still not an exact science. Without warning, on December 26, 2004, an undersea earthquake off the northern coast of Sumatra, Indonesia triggered a tsunami that killed more people than any tsunami in recorded history—at least 283,100 with an additional 14,100 unaccounted for and missing.

As our understanding of the underlying forces that cause earthquakes and volcanoes increases, so will our ability to save lives. We now know that one indication of impending volcanic eruptions is a cluster of imperceptible-to-human earthquakes. The invention of the seismograph in 1880 made it possible to detect these small earthquakes and also to measure the velocity of earthquake waves. As early as 1872, a scientist determined that earthquakes usually occur along fault lines. After the San Francisco earthquake of 1906, another scientist proposed that earthquakes result when built-up pressure along fault lines is suddenly released.

In 1910, a German meteorologist and astronomer named Alfred Wegener (1880–1930) published a book describing a theory he called Plate Tectonics. The essentials of the theory are:

- The lithosphere—the "crust" of the Earth—is composed of several massive plates.
- These plates sit atop the Earth's semi-solid mantle and as the magma (molten rock) within the mantle slowly moves, the overriding plates of the crust move with it.
- The movements of the plates build up pressure along the edges or boundaries of two plates. When the pressure is released, an earthquake and/or volcanic eruption occurs.

Although Wegener was severely criticized for his ideas, the theory was later verified by additional research. However, the theory of plate tectonics was not widely accepted until the latter part of the last century.

Activity Overview

The purpose of this activity is to increase understanding of the Theory of Plate Tectonics and visualize how it is used to explain earthquake and volcano locations. This will be done by assembling a puzzle of the Earth's major tectonic plates then plotting and analyzing the location of a list of earthquakes and volcanic eruptions that have occurred around the world.

Pre-Activity Questions *(Answer on a separate sheet of paper.)*

1. How is the theory of plate tectonics related to earthquake and volcanic activity?
2. Why is the study of earthquakes and volcanoes important?

Materials *(per pair of students)*

- Colored pencils, 2 different colors
- Earthquake Data List
- Physiographic chart of the ocean floor
- Puzzle pieces
- Rulers, 2
- Scissors
- Tape, transparent
- Volcano Data List
- Washable fine point markers (optional)

Safety Precautions

Although materials in this activity are considered nonhazardous, please follow all normal laboratory safety procedures. Exercise care when using scissors to cut out the puzzle pieces.

Procedure

Part 1

1. Work with a partner throughout the entire activity. Obtain one sheet of puzzle pieces and a physiographic chart of the ocean floor from the instructor.
2. Cut out and correctly arrange the puzzle pieces on top of the physiographic chart. *Note:* The correctly arranged pieces will cover all of the chart except the portion from 0° to 30° E.
3. Have the instructor check to ensure that all the pieces are placed correctly. Upon approval, use clear tape to attach all the pieces together. *Note:* Do not attach the puzzle to the physiographic chart.

Part 2

1. Obtain a copy of the Earthquake Data List and two rulers.
2. Plot the location of forty-five (45) earthquakes from the list onto the physiographic chart using the latitude and longitude numbers. Use one color of a colored pencil or marker to show the location of each earthquake by making a small circle or dot. The rulers will help in plotting the locations more precisely.
3. Obtain a Volcano Data List and plot the location of the 45 volcanoes using the latitude and longitude numbers. Use a colored pencil or marker of a different color to show the location of each volcano by making a small circle or dot.
4. In the lower left corner of the chart, make a legend indicating which colors represent earthquakes versus volcanoes.

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Name: ______________________________

Mapping Earthquakes and Volcanoes Worksheet

Post-Activity Questions

1. Look carefully at the marked physiographic ocean chart. Are the locations of earthquakes and volcanoes randomly scattered over the Earth or do they seem to be more concentrated in certain areas? Explain your answer.

2. Which area of the world had the most volcanic activity according to the data provided?

3. Which area of the world had the most earthquake activity according to the data provided?

4. The physiographic chart shows many geologic features of the ocean floor. Write the names of the major geologic features of the ocean floor that are located at or very near the location of the earthquakes and volcanoes that were plotted, i.e., basins, ridges, rises, trenches.

5. Look carefully at the marked chart and assembled puzzle. If the edges of each crustal plate "puzzle" piece represent crustal plate boundaries, describe the relationship between the location of volcanoes and earthquakes and the boundaries of the crustal plates. Be specific.

Challenge Questions:

6. Look carefully at the marked chart and a textbook, if necessary, to answer Questions #6*a* and #6*b*.
   a. Which geologic feature(s) of the ocean floor do you think have been formed by crustal plates moving together?

   b. Which geologic feature(s) of the ocean floor do you think have been formed by crustal plates moving apart?

7. Obtain a copy of the table containing the combined Richter and Modified Mercalli Scales. Use the table, the Earthquake Data List, the physiographic chart, and the assembled puzzle to answer the questions below.
   a. According to the Mercalli Scale, how many of the earthquakes listed would have been felt by all people in the area?

   b. According to the data, how many of the earthquakes would be described as moderate?

   c. Which tectonic plates were involved in producing the strongest earthquake listed?

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Volcano Data List

Volcano	Region	Location
Soputan	Sulawesi, Indonesia	1.1°N, 124.7°E
Anatahan	Mariana Islands	16.4°N, 145.7°E
Canlaon	Philippines	10.4°N, 123.1°E
Chikurachki	Kurile Island, Russia	50.3°N, 155.5°E
Colima	Mexico	19.5°N, 103.6°W
Fuego	Guatemala	14.5°N, 90.9°W
Karymsky	Kamchatka, Russia	54.0°N, 159.5°W
Kilauea	Hawaii, USA	19.5°N, 155.3°W
Reventador	Ecuador	0.1°S, 77.7°W
Santa Maria	Guatemala	14.8°N, 91.6°W
Shiveluch	Kamchatka, Russia	56.7°N, 161.4°E
Soufriere Hills	Montserrat, West Indies	16.7°N, 62.2°W
Mount St. Helens	Washington, USA	46.2°N, 122.2°W
Tungurahua	Ecuador	1.5°S, 78.4°W
Karthala	Comoros Islands, Indian Ocean	11.8°N, 43.4°E
Aso	Kyushu, Japan	32.8°N, 131.1°E
Kliuchevskoi	Kamchatka, Russia	56.1°N, 160.6°E
Krakatau	Sunda Strait, Indonesia	6.1°S, 105.4°E
Popocatepetl	Mexico	19.0°N, 98.6°W
Talang	Sumatraz, Indonesia	1.0°S, 100.7°E
Villarrica	Chile	39.3°S, 71.9°E
Ulawun	New Britain, Papua New Guinea	5.1°S, 151.3°E
Ebeko	Kuril Islands, Russia	50.7°N, 156.0°E
Manam	Papua New Guinea	4.1°S, 145.0°E
Bagana	Bougainville Island, Papua New Guinea	6.1°S, 155.2°E
Suwanose-Jima	Ryukyu Islands, Japan	29.6°N, 129.7°E
Atka	Aleutian Islands, USA	52.4°N, 174.2°W
Egon	Flores Island, Indonesia	8.7°S, 122.6°E
Spurr	Southwestern Alaska, USA	61.3°N, 152.3°W
Veniaminof	Alaska Peninsula, USA	56.2°N, 159.4°W
Karangetang	Siau Island, Indonesia	2.8°N, 125.4°E
Piton de la Fournaise	Reunion Island, Indian Ocean	21.2°S, 55.7°E
Soufriere St. Vincent	St. Vincent Island, West Indies	13.3°N, 61.2°W
Etna, Sicily	Italy	37.7°N, 15.0°E
Galeras	Colombia	1.2°N, 77.4°W
Poas Volcano	Costa Rica	10.2°N, 84.2°W
Sangay	Ecuador	2.0°S, 78.3°W
Nviragongo	Democratic Republic of the Congo	1.5°S, 29.3°E
Erta Ale	Ethiopia	13.6°N, 40.7°E
Oyama	Miyakejima, Japan	34.1°N, 139.5°E
Ruapehu	New Zealand	39.3°S, 175.6°E
Grimsvötn	Iceland	64.5°N, 17.3°W
Shishaldin	Unimak Island, Alaska	54.8°N, 163.9°W
Asama	Honshu, Japan	36.4°N, 138.5°E
Mauna Loa	Hawaii, USA	19.5°N, 155.6°W

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Earthquake Data List

Earthquake Region	Magnitude	Date	Location
Los Angeles, CA	4.5	January 9, 2009	34.1° N, 117.3° W
Luzon, Philippines	5.1	January 9, 2009	16.1 N°, 119.8° E
Bolivia	4.7	January 9, 2009	19.3 S°, 66.6° W
Southern Peru	4.3	January 7, 2009	15.9° S, 69.4° W
Alaska	4.3	January 7, 2009	54.1° N, 165.3° W
Southern Japan	5.0	January 6, 2009	24.1° N, 124.0° E
Japan	5.1	January 5, 2009	37.7° N, 142.9° E
Mariana Islands	4.8	January 5, 2009	20.1° N, 147.0° E
Azores Islands	4.9	January 5, 2009	42.4° N, 30.6° W
Southern Greece	4.2	January 4, 2009	36.8° N, 22.3° E
Nicobar Islands, India	5.3	January 4, 2009	6.3 N°, 94.1° E
Northern California	4.2	January 4, 2009	38.8° N, 122.8° W
Santa Cruz Islands	5.4	January 3, 2009	12.4° S, 166.7° E
Bouvet Island Region, Antarctica	5.8	November 14, 2008	53.7° S, 8.8° E
Oregon Coast	5.4	November 14, 2008	43.6° N, 127.5° W
Gulf of California	4.7	November 13, 2008	24.2° N, 109.1° W
South Sandwich Islands	5.6	November 13, 2008	56.0° S, 27.3° W
Puerto Rico	4.7	November 13, 2008	19.5 N, 66.4° W
Democratic Republic of the Congo	5.0	November 13, 2008	6.4° S, 26.9° E
Fiji	5.0	November 13, 2008	21.8° S, 178.1° W
Costa Rica	5.3	November 13, 2008	10.8° N, 86.1° W
Northern Mariana Islands	4.6	November 13, 2008	18.4° N, 145.3° E
Vanuatu	4.9	November 12, 2008	17.4° S, 167.2° E
Central Turkey	4.6	November 12, 2008	38.9° N, 35.5° E
Philippines	5.0	November 12, 2008	7.0° N, 126.3° E
Carlsberg Ridge, Indian Ocean	5.0	November 11, 2008	0.0° N, 67.2° E
Qinghai, China	5.4	November 11, 2008	37.6° N, 95.8° E
Southern Iran	4.9	November 11, 2008	26.7° N, 54.9° E
Guatemala	4.9	November 11, 2008	14.1° N, 90.7° W
Myanmar	4.8	November 11, 2008	19.3° N, 95.3° E
Sumatra, Indonesia	5.0	November 11, 2008	4.2° S, 102.2° E
Halmahera, Indonesia	4.9	November 10, 2008	1.8° N, 127.4° E
Northern Peru	4.6	November 10, 2008	8.8° S, 79.2° W
Papua New Guinea	4.8	November 10, 2008	5.6° S, 151.9° E
Aleutian Islands, Alaska	4.3	November 10, 2008	51.2° N, 178.4° W
Hokkaido, Japan	4.7	November 10, 2008	45.2° N, 145.3° E
Kermadec Islands	5.2	November 10, 2008	32.1° S, 179.2° W
Sumatra, Indonesia	5.2	November 10, 2008	0.2° S, 100.0° E
Fiji	5.1	November 10, 2008	17.9° S, 178.5° W
Southern Alaska	4.3	November 9, 2008	60.0° N, 153.2° W
Chile	4.8	November 9, 2008	30.6° S, 70.7° W
Tonga	5.5	November 8, 2008	15.2° S, 174.2° W
Sakha, Russia	5.1	November 8, 2008	56.8° N, 123.0° E
Tajikistan	4.3	November 8, 2008	38.6° N, 69.5° E
Banda Sea	6.2	November 7, 2008	6.8° S, 129.3° E

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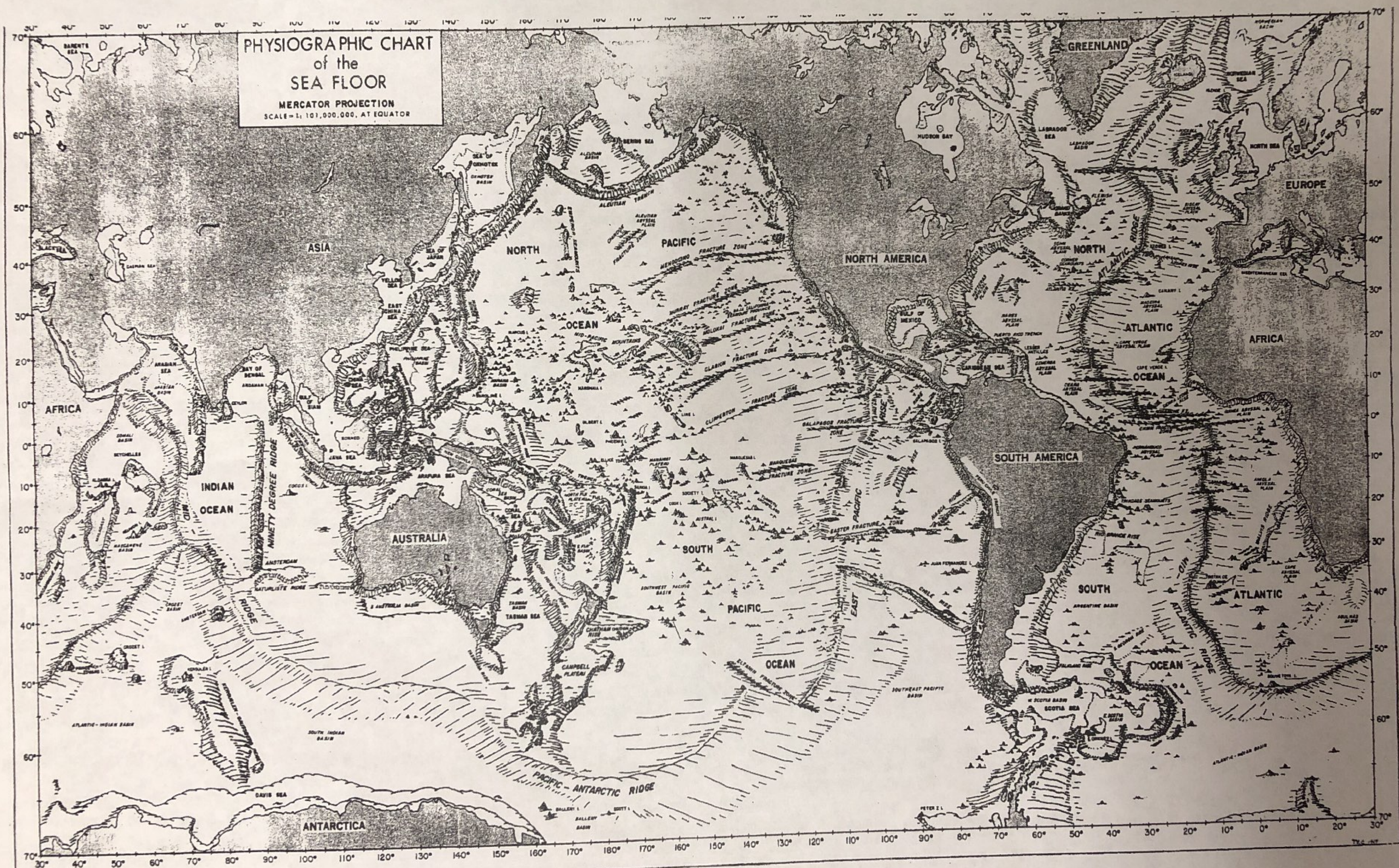
PHYSIOGRAPHIC CHART
of the
SEA FLOOR
MERCATOR PROJECTION
SCALE = 1: 101,000,000, AT EQUATOR
ASIA
NORTH PACIFIC OCEAN
NORTH AMERICA
GREENLAND
EUROPE
AFRICA
NORTH ATLANTIC OCEAN
MID-ATLANTIC RIDGE
SOUTH AMERICA
INDIAN OCEAN
NINETY DEGREE RIDGE
AUSTRALIA
SOUTH PACIFIC OCEAN
EAST PACIFIC RISE
SOUTH ATLANTIC OCEAN
PACIFIC - ANTARCTIC RIDGE
ANTARCTICA
HUDSON BAY
SCOTIA SEA
DAVIS SEA
TASMAN SEA
BERING SEA
ALEUTIAN TRENCH
CLIPPERTON FRACTURE ZONE
CLARION FRACTURE ZONE
MURRAY FRACTURE ZONE
MENDOCINO FRACTURE ZONE
GALAPAGOS FRACTURE ZONE
MARQUESAS FRACTURE ZONE
EASTER FRACTURE ZONE
CAMPBELL PLATEAU
LABRADOR SEA
NORTH SEA
NORWEGIAN SEA
CASPIAN SEA
ARABIAN SEA
BAY OF BENGAL
GULF OF MEXICO
CARIBBEAN SEA

HUBBARD