Student Activity: Science on a Sphere

During today's activity you will take a trip into space using NOAA's Science on a Sphere (SOS) program, which uses animations and computers to display information about our planet. From here, you'll be able to get any view of the Earth that you need to explore more about plate tectonics. Read through the scenarios below and answer the questions – the pictures are still shots taken from SOS videos. Other resources you may find helpful in answering the questions are a global map from your classroom and/or the Plate Boundary map included in this activity.

<u>The Bathymetry of Earth's Ocean</u>

Let's take a look at some of the topographic and bathymetric features of Earth. **Bathymetry is the measurement of the ocean depths** and underwater terrain; bathymetric maps show the topography of the sea floor.

The pictures below are a global relief model of Earth's surface that integrates land topography and ocean bathymetry. It was built from numerous global and regional data sets. Scientists use high resolution maps like these to improve accuracy in tsunami forecasting, modeling, and warnings, and also to enhance ocean circulation modeling and Earth visualization.

Notable Features:

- Marianas Trench: deepest point on Earth at 36,201 ft
- Mid-Atlantic Ridge: longest mountain range
- Mount Everest: tallest point on Earth at 29,035 ft

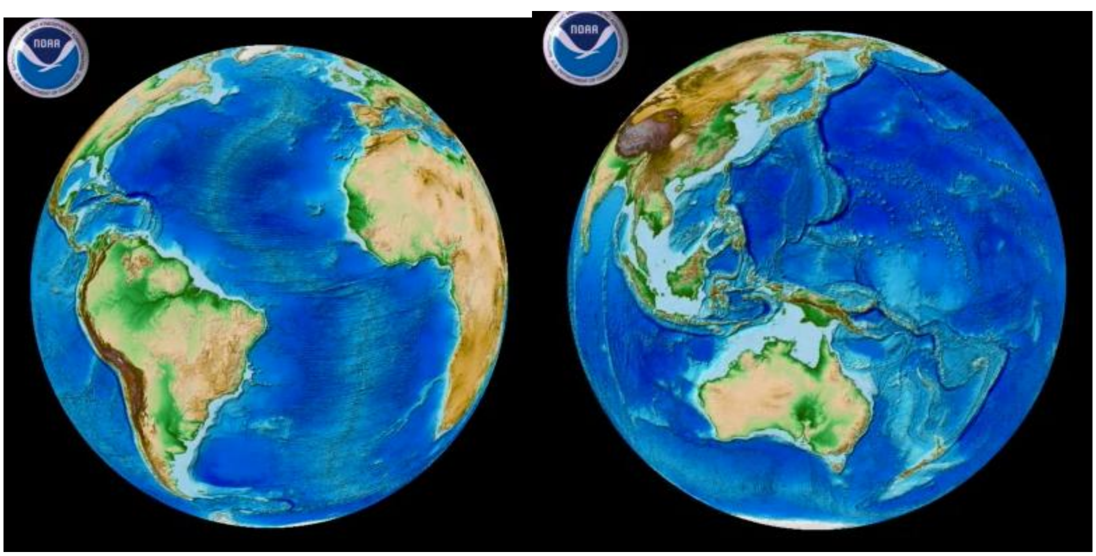


Fig 1. Two screen shots of a bathymetric map of Earth showing the Mid-Atlantic Ridge (left) and the Marianas Trench (right).

Plate tectonics

Plate tectonics are responsible for the geological features you see in the pictures above. The architecture of Earth looks very different than it did millions of years ago, when the continents existed as one large land mass called Pangaea. Let’s look at the evolution of ocean basins and continental placement due to plate tectonics.

The pictures below are from a time-elapsed frame set of approximately 4000 high-resolution images with original artwork visualizing the evolution of the Earth's surface due to plate tectonics over the past 600 million years.

Drift animations show the motions of the continents and the evolution of the ocean basins from the late Precambrian (750 million years ago), through the assembly and breakup of Pangea (250 million years ago), and extends the modern plate motions +250 million years into the future (Pangea Ultima). The whole animation is approximately 8000 frames. Both datasets show the large southern landmass called Pannotia, which began to break apart into several small pieces as well as Gondwana 550 million years ago, which eventually became the cores of North America, Northern Europe, and Siberia. The smaller pieces from the break up of Pannotia drifted together to form Laurasia. Gondwana and Laurasia drifted for more than 200 million years, and then came back together again, pushing up a great mountain range of which the Appalachian Mountains are one remnant.

This new super continent, Pangaea, then began its break up around 300 million years ago into what became the present day world. During the Jurassic period, 140-180 million years ago, the North Atlantic opened up, followed by South America and Africa pulling apart to create the South Atlantic, and then the final break up of Gondwana into India, Australia, and Antarctica. When India broke free from other landmasses, it traveled with great speed toward current day Asia. The collision between the two land masses caused the Himalayas to form. Also during this time, several mass extinctions occurred due to various warming and cooling events.

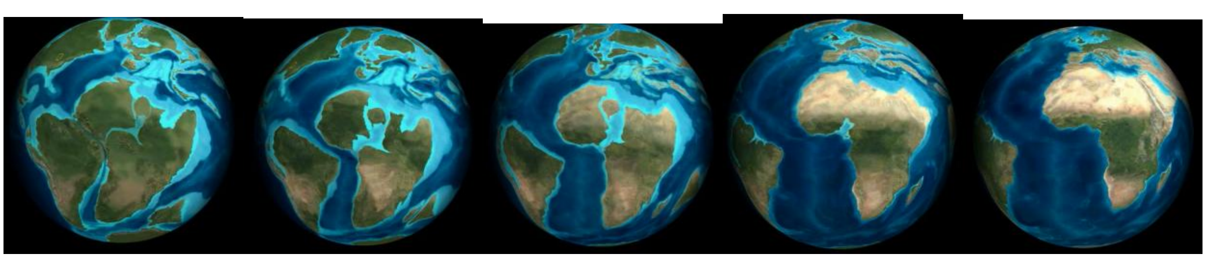


Fig 2. Screen shots from a plate tectonic animation showing the break-up of the super-continent Pangaea over time from left (oldest) to right (youngest).

Tectonic Activity and Natural Disasters

It is important to study plate tectonics not only to understand the geological features of Earth, but also to help us understand and prepare for disasters like earthquakes, tsunamis and volcanoes.

Earthquakes

Tectonic earthquakes are naturally occurring and are caused by earth movement. The surface of the Earth is composed of a mosaic of tectonic plates moving with respect to each other. When two plates glide past one another, a stress builds up at the boundary. When that stress reaches a critical level, the boundary slips and the result is an earthquake. The traces of repeated slips are known as fault lines.

The Richter magnitude scale was created to rate the strength and magnitude of earthquakes. It is a base-10 logarithm scale of ground motion 100km from the epicenter. Each increase of 1 magnitude means 10 times greater ground motion. To measure the amount of energy that was released during an Earthquake, a base 32 logarithm scale is used.

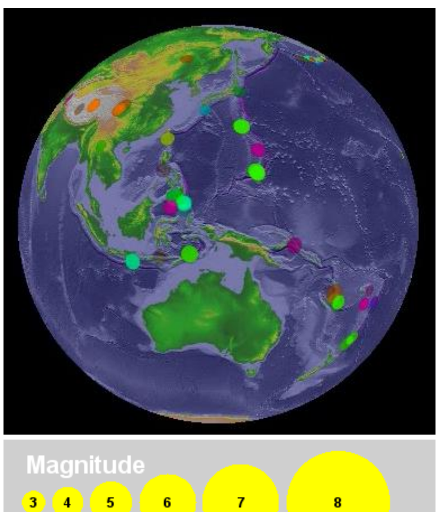


Fig 3. Screen shot of earthquakes, indicated by colored circles according to magnitude and depth.

The picture at the left is from a real time data set (2010) that shows the earthquakes that daily happen around the world that are greater than 2.5 on the Richter scale. The size of the circle is proportional to the magnitude of the earthquake, with bigger values on the Richter scale represented by bigger circles. The coloring of the circles is based on the depth of the earthquake below the surface according to the provided color bar. After an earthquake occurs, the representing circle fades out over a seven day period. This dataset is updated hourly.

Volcanoes

Volcanoes typically form in three different settings. The first is divergent plate boundaries, where tectonic plates are pulling apart from one another, such as the Mid-Atlantic Ocean Ridge. Most of these volcanoes are on the bottom of the ocean floor and are responsible for creating new sea floor. The second location is convergent plate boundaries, where two plates, typically an oceanic and continental plate, are colliding. The volcanoes along the Pacific Ring of Fire are from convergent plate boundaries. The third location is over hotspots, which are typically in the middle of tectonic plates and caused by hot magma rising to the surface. The volcanoes on Hawaii are the result of hotspots.

The pictures below show the locations of significant eruptions, of which there are over 400. An eruption if considered significant if there are any fatalities linked to it, the cost of the damage is over one million dollar, it causes a tsunami or there is a major earthquake associated with it.

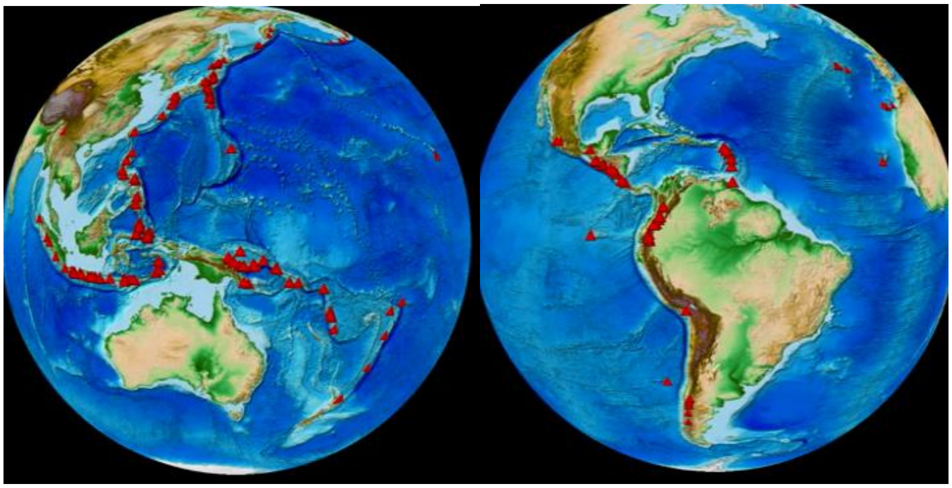
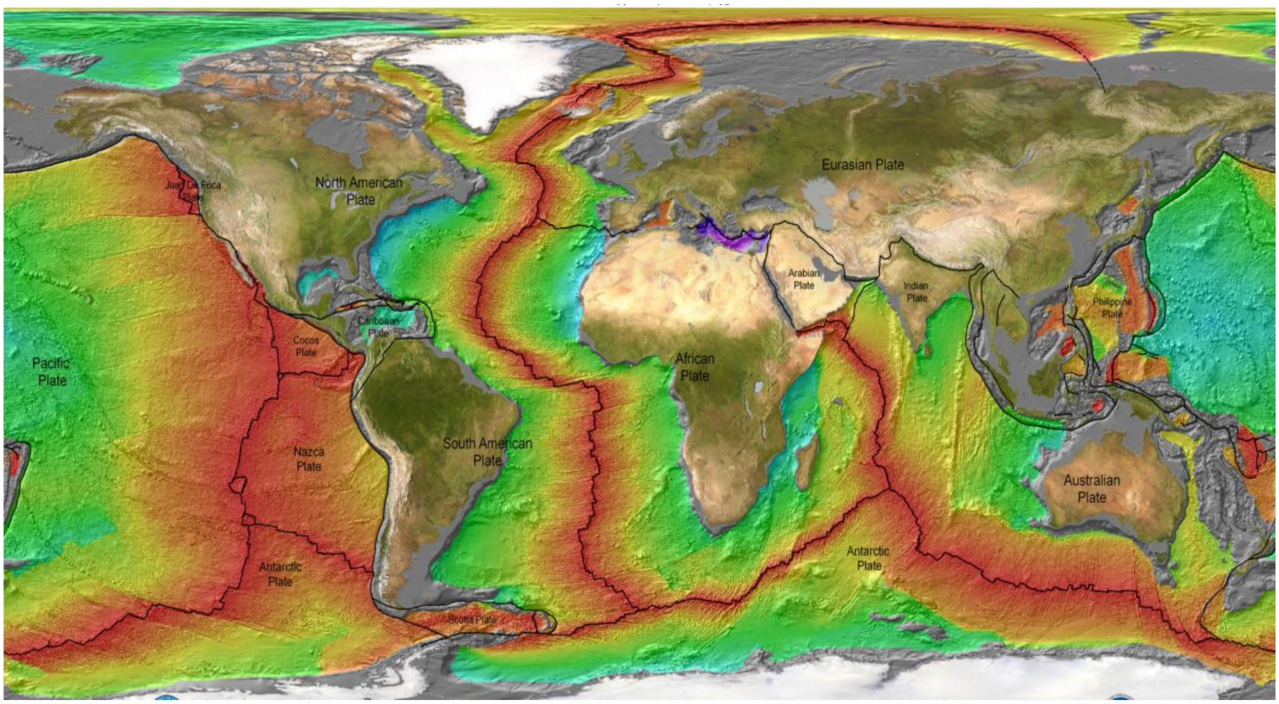


Figure 4. Screen shots showing where significant volcanic eruptions have occurred (red triangles) from two different views of Earth.

Map of Earth’s Plate Boundaries



Questions

1. Describe the bathymetry of Earth that you see in the Fig 1. Is the terrain flat? List the features that you see.

2. What is the longest mid-ocean ridge? Is it visible in the screen shots shown in Fig 1? How did this ridge form?

3. Can you see any trenches in Fig 1? Is the deepest trench in the ocean taller or shorter than the highest mountain on land? Where is this trench located?

4. How do these trenches form?

5. When did the ‘super continent’ Pangaea start to break apart?

6. What two landmasses collided to form the Appalachian Mountains? What type of plate movement caused the mountains to form? Can you name another large mountain range that formed because of this type of plate movement?

7. Collision of which two land masses caused the Himalayas to form?

8. Describe the distribution of the following natural disasters and name a few locations you see them occur in Figs 3 and 4:
    a. Earthquakes

    b. Volcanoes

    c. Where do these disasters tend to occur relative to plate boundaries?

9. Some earthquakes are related to plate tectonics. What type of plate movement results in an earthquake? What well-known geological feature results in earthquakes in California?

10. The descriptions on some of the SOS videos indicate that data about plate movement can help scientists predict and prepare for tsunamis. How do you think the data you’ve seen today could help to predict and prepare for these events?

Teacher's Edition: Science on a Sphere

Questions

1. Describe the bathymetry of Earth that you see in the Fig 1. Is the terrain flat? List the features that you see.

   Students should describe ridges and trenches and their locations.

2. What is the longest mid-ocean ridge? How did this ridge form?
   The Mid-Atlantic Ridge in the Atlantic Ocean. It is visible in the screen shot, and formed by a divergent boundary.

3. Did you see any trenches on the video? Is the deepest trench in the ocean taller or shorter than the highest mountain on land? Where is this trench located?
   Trenches are visible on the video. The Marianas Trench east of Japan is the deepest trench on Earth. It is deeper than the highest mountain (Mount Everest) is tall.

4. How do trenches form?
   A trench forms when subduction occurs as an oceanic plate moves beneath a continental plate.

5. When did the 'super continent' Pangaea start to break apart?
   Around 300 million years ago.

6. What two landmasses collided to form the Appalachian Mountains? What type of plate movement caused the mountains to form? Can you name another large mountain range that formed because of this type of plate movement?

   Gonwana and Laurasia. Convergent plate movement. Other examples include the Himalayas, the Cascade Mountain range, and Andes mountains.

7. Collision of which two land masses caused the Himalayas to form?

   Indo-Australian plate and Eurasian plate (India and Asia also acceptable).

8. Describe the distribution of earthquakes and their magnitude across the globe. Name a few locations where you see them occurring.
   Answers will vary.

9. Some earthquakes are related to plate tectonics. What type of plate movement results in an earthquake? What well-known geological feature results is associated with earthquakes in California?

A transform boundary or fault is the nexus where two plates slide past one another. When disruptions occur along these boundaries, earthquakes can occur. The San Andreas Fault is in CA.

10. The descriptions on some of the SOS videos indicate that data about plate movement can help scientists predict and prepare for tsunamis. How do you think the data you've seen today could help to predict and prepare for these events?
    Tsunamis can be triggered by earthquakes in the sea. The data sets on the SOS site can be used to identify where these earthquakes are likely to occur for monitoring. When earthquakes do occur, scientists can then predict who is likely to be affected by an impending tsunami.