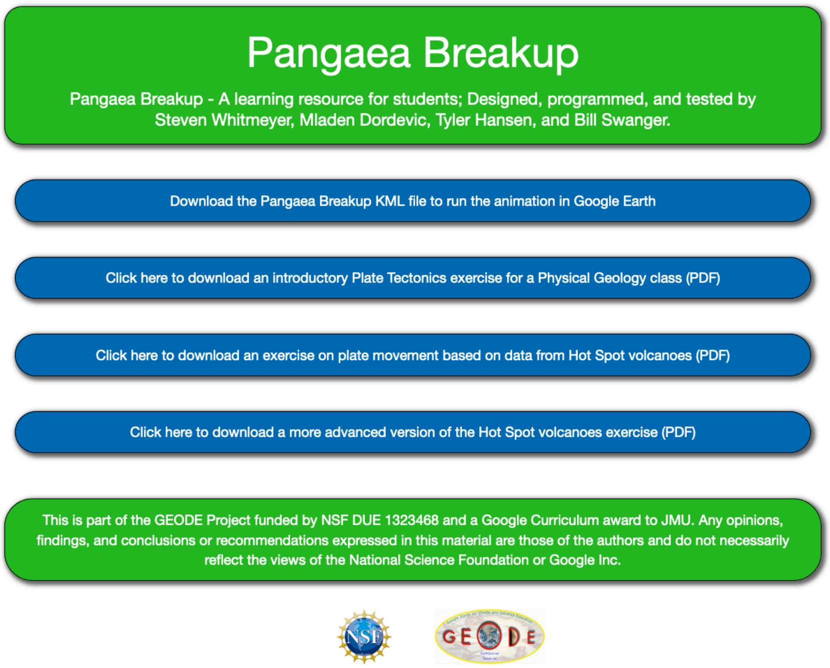
Plate Tectonics Exercise

Step 1:

On your PC or laptop go to the web URL below:

http://csmgeo.csm.jmu.edu/Geollab/Whitmeyer/geode/pangaeaBreakup/

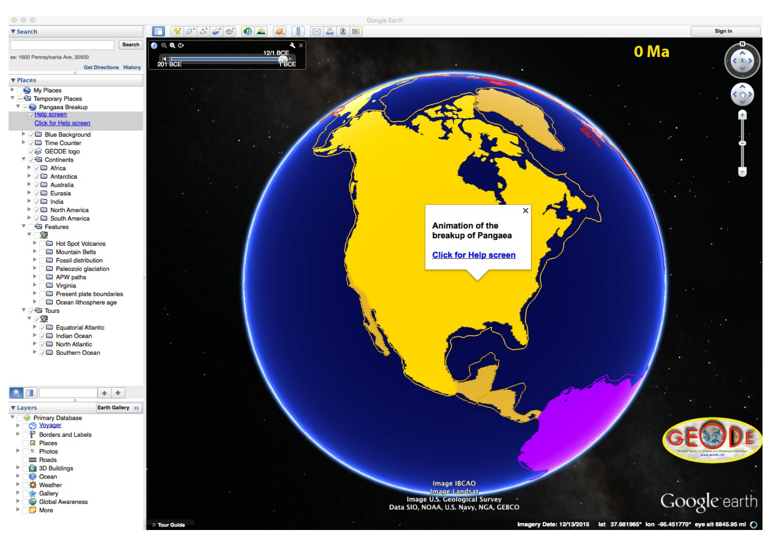
You should see the following webpage:



Click the upper blue button to download the Pangaea Breakup KML file to use the animation in the Google Earth application (which needs to be installed on your computer). To download Google Earth for your computer, go here:

https://www.google.com/earth/download/ge/agree.html

Once you have everything installed and have opened the Pangaea Breakup.kml file in Google Earth, a virtual globe rendering of the supercontinent Pangaea (like the image to the right) should appear after a few minutes (this may take longer on an off-campus computer.)



Step 2:
At this point you should see something like the image at the bottom of the previous page. This is a virtual globe animation of the supercontinent Pangaea and its subsequent breakup spanning the time period from 200 Ma (million years ago) to the present.

Spend the next several minutes exploring the various aspects of the Pangaea Breakup interactive animation.

Things to note:

- On the left side of the Google Earth window, you will see a "Places" window that has the Pangaea Breakup folder list under the "Temporary Places" folder. You will use the selection boxes for the folders listed under the Pangaea Breakup heading to control what is shown in the main Google Earth window
- Underneath the "Places" window you will see a "Layers" window. Make sure to deselect (turn off) the "Primary Database", which should be the top item in the Layers window
- Now looking at the main Google Earth window (that shows the virtual globe), you can rotate the virtual globe to any desired viewpoint by clicking on the globe and moving your mouse while holding down the mouse button
- The time period in Ma (millions of years ago) for the currently-displayed arrangement of continents is shown in yellow at the upper right of the screen
- In the upper right corner is a vertical scale bar that you can drag up and down to zoom in and out of specific locations
- You can change the geologic time period shown by sliding the white tab on the blue bar at the top left corner of the window
- In the "View" dropdown menu at the top of the screen you can toggle a latitude and longitude grid by clicking "Grid"
- Continents can be selected and deselected via checkboxes by each continent name in the "Places" window
- Other features, such as Mountain Belts, Hot Spots, Fossil Distribution, etc. can be shown using the checkboxes in the "Features" menu
- Explore automated animations of the breakup of Pangaea from various viewpoints by selecting a location in the "Tours" menu

Once you have familiarized yourself with the Pangaea Breakup interactive animation, proceed with the exercise that follows.

Name(s)____ Date_____________

____________________ ____________________

Plate Tectonics Exercise

Background – Plate tectonics describes the Earth's crust as being a rigid exterior, which is divided into several slabs, or "plates", which are located above the convecting mantle and move through time. Dissipation of heat from the Earth's interior drives plate movement. The boundaries between plates can be convergent (collisional), divergent (extensional), or side-to-side movement (strike-slip or transform movement) and typically feature mountain ranges.

The theory of plate tectonics was influenced by Alfred Wegener's hypothesis of continental drift, introduced in 1915. Wegener suggested that there was once a single land mass, or supercontinent, that he referred to as "Pangaea." Some of the evidence that Wegener used included: the apparent jigsaw fit of the continents, fossil evidence, evidence of past glaciations, and the correlation of ancient mountain belts across continents.

We will explore this evidence for plate movement in this exercise. Use the Pangaea Breakup model to answer the following questions.

Jigsaw fit of the Continents – The Pangaea Breakup model shows the movement of tectonic plates over the last 200 million years. It shows, in detail, the movement of plates that Wegener proposed in 1915. Explore plate movement / continental drift by answering the questions below.

1. When Pangaea was still a supercontinent (200 Ma), which present-day continent was partially located at the North Pole (HINT: Turn on Grid)?
    a. Antarctica
    b. Australia
    c. Eurasia
    d. North America

2. Approximately how many millions of years ago (Ma) did present-day India break away from present day Madagascar?
    a. 20 Ma
    b. 50 Ma
    c. 80 Ma
    d. 120 Ma

3. From 90 Ma to the present, which continent / landmass travelled the greatest distance (HINT: Turn on Grid and estimate degrees of latitude or longitude)?

a. Africa
b. India
c. North America
d. South America

4. In terms of its geographic location, which modern day continent is closest to where it was at 200 Ma?

a. North America
b. South America
c. Antarctica
d. Australia

<u>Mountain Belts</u> – The correlation of ancient mountain belts across now separated continents was another piece of evidence that supported the idea of continental drift. Select "Mountain Belts" and explore this idea by answering the questions below.

5. Which mountain belts were adjacent to each other prior to the breakup of Pangaea (HINT: Zoom in or click on the green mountain symbols)?

a. Cascade and Mauritanian (western Africa) mountains
b. Ouachita (SE North America) and Greenland mountains
c. Greenland and Caledonian (western Europe) mountains
d. Mauritanian and Sierra Nevada mountains

6. What mountain belts on now-separated continents were likely connected as a single mountain belt on the supercontinent of Pangaea?

a. The Andes and the Rockies
b. The Alps and the Atlas (Africa) Mountains
c. The Sredinny Range (eastern Asia) and the Sierra Nevada Mountains
d. The Australian Alps and the Transantarctic Mountains

7. A section of the Southern Appalachian Mountains are located in Virginia (Select "Virginia"). Which mountain belt was next to the Virginia Appalachians at 200 Ma?

a. The Atlas Mountains
b. The Caledonian Mountains
c. The Greenland Mountains
d. The Mauritanian Mountains

<u>Fossil Evidence</u> – The presence of the same fossil species in now separated continents is further evidence for continental drift. Select "Fossil distribution" to explore this idea in the questions below.

8. Which fossils are found in Southern Africa (HINT: Zoom in or click on the fossil symbols)?
   a. Cynognathus
   b. Lystrosaurus
   c. Mesosaurus
   d. All of the above

9. Glossopteris is an ancient fern-like fossil found on Antarctica. Where else can this fossil be found?
   a. India
   b. Australia
   c. Southern Africa
   d. All of the above

10. Mesosaurus is a fresh-water reptile fossil found on continents in the southern hemisphere. Based on the locations of these fossils, which continents with Mesosaurus fossils were likely adjacent to each other?
   a. Antarctica and India
   b. Africa and South America
   c. Australia and India
   d. North America and Europe

<u>Glacial Evidence</u> – Paleozoic glaciations that can be found at locations on several continents are evidence that the continents were once connected. Select "Paleozoic glaciation" and explore this idea by answering the questions below.

11. Which modern day continent does not show evidence of Paleozoic glaciation?
   a. Australia
   b. Africa
   c. North America
   d. South America

12. Glacial evidence located near the equator today suggests that those continents were once located in colder regions near the poles. Which continents have glacial evidence near the equator today?
   a. Australia and Antarctica
   b. Africa and South America
   c. North America and Eurasia
   d. All of the above

Modern Plate Tectonics

Plate Boundaries – There are 3 basic types of plate boundaries:
Convergent – When plates come together. One plate will be subducted under the other. This forms features such as mountains, island arc systems, and ocean trenches.
Divergent – When plates move apart. This creates spreading centers that show up as sea floor spreading zones in oceanic crust, and rift valleys in continental crust.
Transform – When plates slide past each other. They are very common in oceans where they offset mid-ocean ridges. They can also form plate boundaries like the San Andreas Fault in California.

Select "Present plate boundaries" and explore **plate boundaries** by answering the questions below. Make sure the time slider is set to the present day (0 Ma).

13. What type of boundary is found between the South American Plate and the Nazca Plate?
    a. Convergent
    b. Divergent
    c. Transform
    d. Undefined

14. What is the main plate boundary type found at the Mid-Atlantic Ridge?
    a. Convergent
    b. Divergent
    c. Transform
    d. Undefined

15. What type of present-day collision formed the Himalayan Mountains at the boundary between the Indian Plate and the Eurasian Plate?
    a. Continent-continent collision
    b. Continent-ocean collision
    c. Ocean-ocean collision
    d. Undefined

16. What type of present-day collision formed the Caribbean Islands along the eastern boundary of the Caribbean Plate and the North / South American Plates (HINT: deselect Blue Background to see the Caribbean Islands)?
    a. Continent-continent collision
    b. Continent-ocean collision
    c. Ocean-ocean collision
    d. Undefined

17. Where is the oldest ocean crust (ocean lithosphere) located (HINT: Select "Ocean lithosphere age" and look for the purple colored bands)?

a. Arctic Ocean
b. Indian Ocean
c. Southern Atlantic Ocean (below the equator)
d. Western Pacific Ocean (near the Antimeridian)

Hot spots – Columns of rising molten material from deep in the mantle, known as "mantle plumes," rise to the surface where the energy is released via "hot spot" volcanoes. When long-lived mantle plumes encounter oceanic crust they create hotspot chains, due to the movement of a tectonic plate over a relatively stationary hotspot. An example of this is the Hawaiian Island chain. When mantle plumes encounter continental crust they create volcanic calderas, such as the Yellowstone Caldera. Select "Hot Spot Volcanos" and explore **hot spots** by answering the questions below.

18. What is the age of the oldest seamount (Detroit Seamount) in the Hawaiian Island chain (HINT: Run the time slider backwards until the Detroit seamount is at the location of the Hawaiian mantle plume)?

a. 6 Ma
b. 34 Ma
c. 39 Ma
d. 78 Ma

19. What is the oldest volcanic feature in the Yellowstone Hot spot chain?

a. Yellowstone Caldera
b. Walcott Tuff
c. Mesa Falls Tuff
d. McDermitt Caldera

20. The Ninety East Ridge hot spots (in the Indian Ocean) initiated with the Kerguelen flood basalt plateaus (outlined with red polygons) that eventually included Broken Ridge. When did the first Kerguelen plateaus <u>start</u> to form?

a. ~50 Ma
b. ~80 Ma
c. ~110 Ma
d. ~140 Ma

Selected References

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