MOUNTAINS AND SEAS IN NC
LESSON

DRIVING QUESTION: HOW DOES PLATE TECTONICS AFFECT NORTH CAROLINA?

Recommended Grades: K – 6; Adaptations for 7 – 12.

Classroom or Center Activities	*Outside or Larger Space Activities*	*Technology-Based Activities*	*Stem-to-Go Take Home*	*Field Work and/or Natural Area Needed*
X	X	X	X	X

Materials: An aluminum or Pyrex pie plate, card stock for the plate tectonic map, scissors, hot water with red coloring added, cold water with blue food coloring added, dropping pipet, maps of North Carolina, Laffy Taffy or Milky Way Bars.

Teacher Prep: <15 Minutes

Participant activity: 30 minutes

Objectives:

1. Identify landforms on the earth: hills, mountains, valleys, ridge, basin, island, sound, piedmont, coastal plain, tidewater.
2. Model convection currents as a force that drives plate tectonics movement.
3. Use maps and graphing activities to identify NC's physiographic provinces.
4. Apply plate tectonics theory to North Carolina's physiographic provinces.

STEM Skills

S: Classify landforms and physiographic provinces of NC. Infer geologic processes that created them.

T: Utilize models to explain plate tectonic movement.

E: Identify slope for potential geologic hazards of landslides and flooding.

M: Graph a journey of NC's I-40 from the mountains to the sea.

Teacher Tips: Mountains and Seas in NC

Plan ahead: Make copies of the plate tectonics map and distribute scissors and pie plates. Mix blue food coloring. Hot water from the tap should be your last step. If you need free NC maps, you can download electronic copies or order hard copies at https://www.visitnc.com/travel-guides. Maps are also available at welcome centers and rest areas across the state.

Total prep: < 15 minutes to make copies

Safety: Hot water from the tap is safer than heating water in a microwave. During the Plate Tectonics Dance, it is helpful to remind participants about personal space and respectful interaction. A reminder regarding personal space during the dance is helpful. If walking outside, make sure to designate boundary areas.

Sensory Integration Issues: If participants' fine motor skills are not adequate for using scissors, tearing the paper works fine, too. During the plate tectonics dance, some participants may not feel comfortable touching. Proximity can be substituted for the whole group, rather than individuals joining hands.

Cost: Minimal, <$1 per person. Generally, snack sized and bulk candies go on sale after Halloween and Easter.

What else do I need? Paper towels/rags.

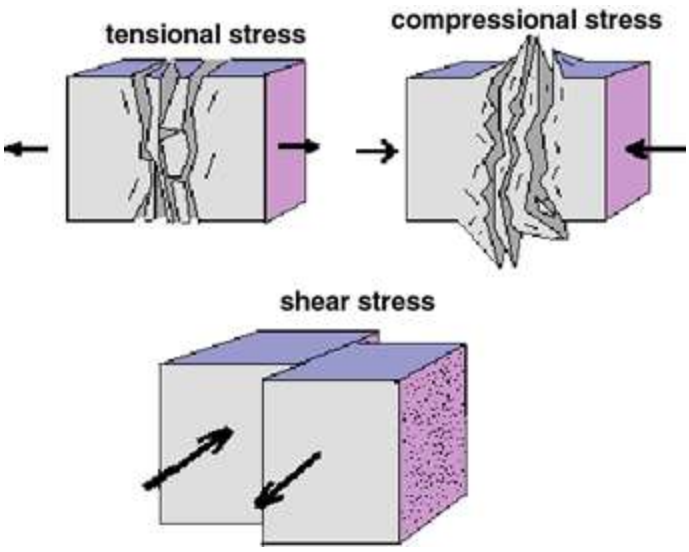
Clean Up: Hands, equipment, and surfaces can be washed with soap and water. Do not pour paper down the sink.

Mountains to the Sea in NC Lesson Plan

1. Print it out:
    a. Print one copy per participant of the NC Physiographic Provinces.
    b. Print one copy per group of the Plate Tectonics Map. Pass out scissors for participants to along the boundaries.
    c. For grades 6 – 12, print one copy per group of the Mountains to the Sea Journey Lab.
    d. Print one copy of the
2. Activate prior knowledge:
    a. Take a Landscape Hike (STEM To-Go): Build upon participants' movement up and down hills, to get an understanding that land has topography, elevation, and relief changes that we can see and hike. The same geological processes that are shaping the earth now, have shaped it in the past. This is an application of James Hutton's Law of Uniformitarianism, eg., "the present is the key to the past"). But sometimes, we cannot observe geologic changes in our lifetime.
    b. Candy Crush for Continents: This activity is appropriate for K – 12, and it is based on Candy Bar Tectonics https://earthref.org/ERDA/download:2058/

        Provide each participant with one Laffy Taffy segment. Participants should carefully unwrap the taffy. They will "stress out" their taffy by folding it, bending it, and tearing it, thus, simulating the three main sources of stress that deform the earth.

        i. Compressional Stress: Press the two ends of taffy together. The candy should fold either up (an anticline) or fold down like in a u-shape (a syncline). Compression causes folding. In landforms, folding shows up as mountains and rolling hills. Compression caused mountains like the Himalayans and the Blue Ridge in NC to be formed. Note that the piece of candy got smaller and folded. This happened in NC when North American and Africa collided together, crunching and folding the continental crust and forming the Blue Ridge, which are part of the Appalachian Mountains. Mount Mitchell is the highest point in NC at 6,684 feet, but our mountains may once have been as tall as the Himalayans at 29,000 feet. Where did the mountains go? They were eroded and carried away by rivers to form the sediments of our coastal plain.



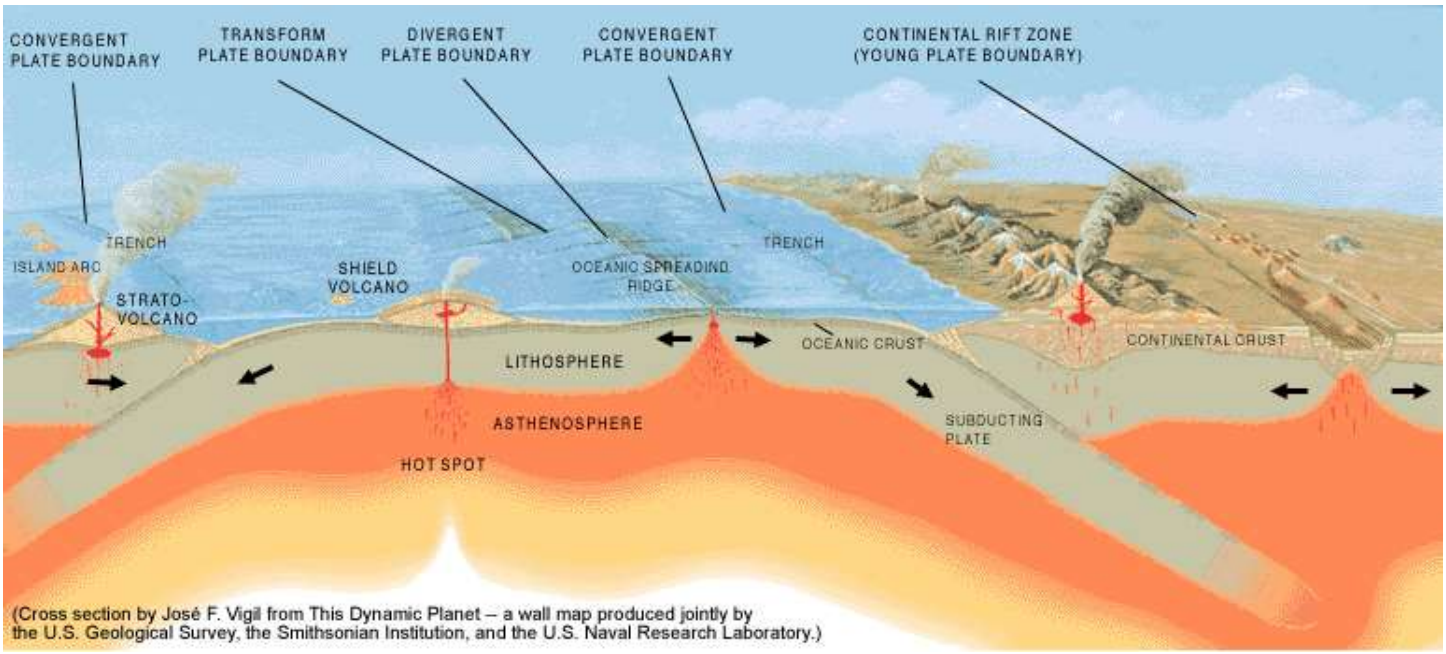
        https://earthquake.usgs.gov/learn/glossary/images/stress_types.gif

        ii. Shear Stress: Hold one end of the taffy still and slide it past/move the other end away from it, making it form an S. Shear stress forms faults, like the San Andreas Fault. Note that the piece of candy got longer and thinner. In NC, as the Appalachian mountains formed, chunks of land called terranes shifted and sheared off each other near Brevard and in parts of the Piedmont, which we can still see in faults left over from earthquakes. https://pubs.geoscienceworld.org/gsa/geology/article-abstract/16/10/915/204586/location-and-geometry-of-alleghanian-dispersal?redirectedFrom=PDF

        iii. Tensional Stress: Pull the taffy straight apart until it breaks. This tensional stress causes rifting or tearing in which new oceanic or continental crust is formed when magma and lava seeps up through the thinning, opening in the crust. The magma then cools to form brand new crust. Off the cost of NC, the Atlantic Ocean is still rifting and tearing apart, which is moving us about 2

centimeters farther away from Europe and Africa each year. This is approximately the rate that a person's fingernails grow. https://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Divergent/Mid-Atlantic-Ridge

c. Plate Tectonics Dance: Explain the motions, then call out the bold letters to "call" the dance steps.
   i. Review the types of stress with hand motions.
      1. Compressional Stress: Two flat hands meet, press together and form an inverted V that looks like a little mountain.
      2. Shear Stress: Slide the sides of your hands past each other, making a whooshing noise.
      3. Rifting: Place your hands parallel to each other and move them quickly away from each other.
   ii. Convergent Plate Boundaries:



https://www.google.com/search?q=plate+boundaries&rlz=1C1GCEA_enUS836US836&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjgio6psPvhAhVJMawKHf65CjYQ_AUIDigB&biw=1354&bih=599#imgrc=bqyYAewXLCs3kM:

1. **Convergent Continent to Continent:** This part of the dance mimics folding, in which mountains are formed.
   a. Participants form two parallel lines with people facing each other. Both lines step towards one another raising their hands, which forms a mountain of triangles between them. Then participants step back to the starting position in the two parallel lines. In NC, North America and Africa collided together, which formed the Appalachian Mountains.
2. **Convergent Ocean to Continent:** Participants form two parallel lines. This part of the dance mimics subduction, when denser oceanic crust is forced beneath the continental crust. But then, the oceanic crust is forced deep within the earth, and melts to form volcanic mountains.
   a. One side spreads out, taking a step away from each other with their hands joined with the person nest to them. They are the less dense continental crust. Then, the opposite line is the denser, oceanic crust. Their job is to duck underneath the joined hands of the continental crust, which then move from parallel to the ground to above their heads, like a mountain. The oceanic crust line then joins one hand to the pair near them and says, "SUBDUCTION

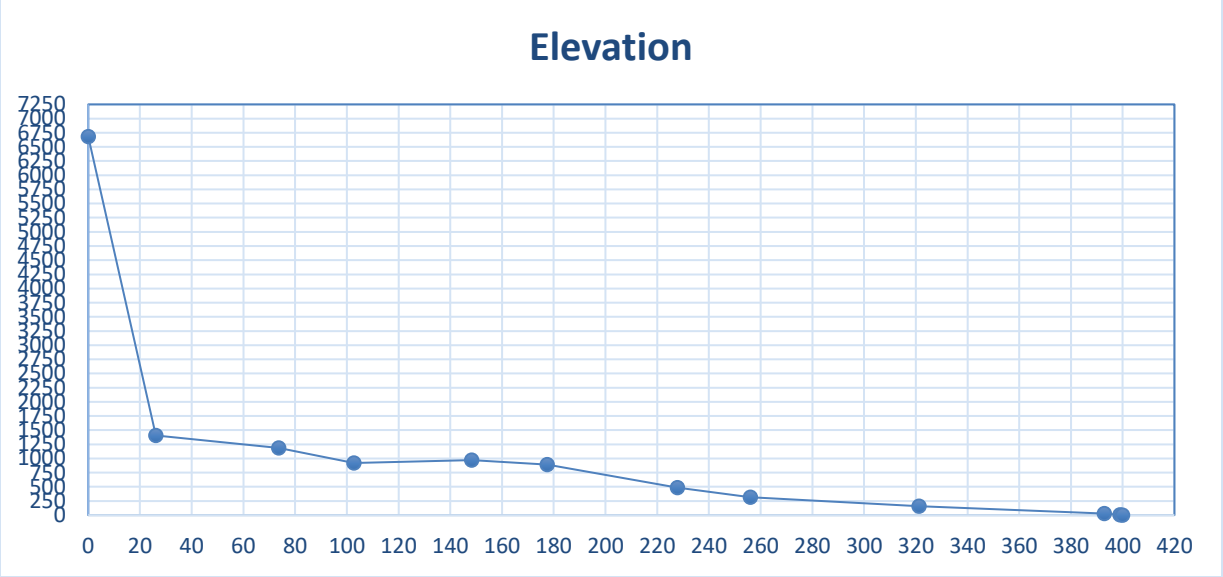
VOLCANOES!" The oceanic crust then joins their hand and "explodes." Then participants step back to their starting position in two parallel lines. There are ancient volcanoes in NC, and many of them formed as island arcs in subduction zones that then got crunched onto our continent when Africa and North America collided to form the Appalachians.

3. **Divergent:** Participants form two parallel lines. This part of the dance mimics rifting or tearing apart of crust. Participants should take three steps away from each other forming a large space. Then, I recommend that the teacher should run between the two lines saying, "MAGMA/RIFT/NEW CRUST!!!!" This is how the Mid-Atlantic Ridge formed. In NC, the Triassic Basins in Durham are remnants of this rifting. Participants should return back to their starting points of two parallel lines.
4. **Transform:** Participants for two parallel lines, then stretch one arm across to join hands with the other line. Then each line should shift two steps to the right. The lines should skew and look like an S. In North Carolina, there are some faults near Brevard that show this type of stress, although we did not have a transform plate boundary. The San Andreas Fault runs along the Transform plate boundary, and that is what causes earthquakes there.

3. Procedure:

a. Distribute the maps of the plate tectonics boundaries. Ask students to cut along the bold/dark lines.
b. Place a pie pan on each table. First mix cold water and blue food coloring. Then mix the hot water and red food coloring.
c. Add the blue water. Ask participants to float the map on the surface. Ask students to draw what they see. While they are drawing, walk around the room to distribute the hot water.
4. Data Collection: Compare the movement of the plates with cold water and warm water added. Draw the convection currents.
5. Collaboration: This activity can be repeated many times to see how the plates move. Is there a pattern in the movement?
6. Data Analysis: As the water cools, the continents' movements should slow.

7. Resources and Adaptations by Participants' Ages:
    a. For K-2: Please pour the hot water for them. For K – 3rd: the teachers should add the hot water with red food coloring to the bottom of the plate by using a dropping pipet or pouring very slowly along the edge. The red food coloring should rise and move through the blue, with currents being visible. Then the plates should move quicker with addition of the hot water. Very slowly pour the red food coloring.
    b. For 3 – 5: Add the warm water around the edges of the plate versus in one spot. That one concentrated spot of hot water simulates a "hot spot" or magma plume that formed Hawaii and Yellowstone.
    c. For 4 – 8: Introduce Part 3, but only focus on the first 4 questions.
    d. For 8 – 12: Include Geohazards and slope as impacting NC. The Blue Ridge Mountains have steep slopes and are vulnerable to landslides. The Coastal Plain is flat, and is at risk for flooding.
8. Clean up and Conclusion: When disposing of the water, make sure that pieces of paper do not clog the drain. Ask your participants which community they live in, and discuss potential hazards they may face.


Elevation
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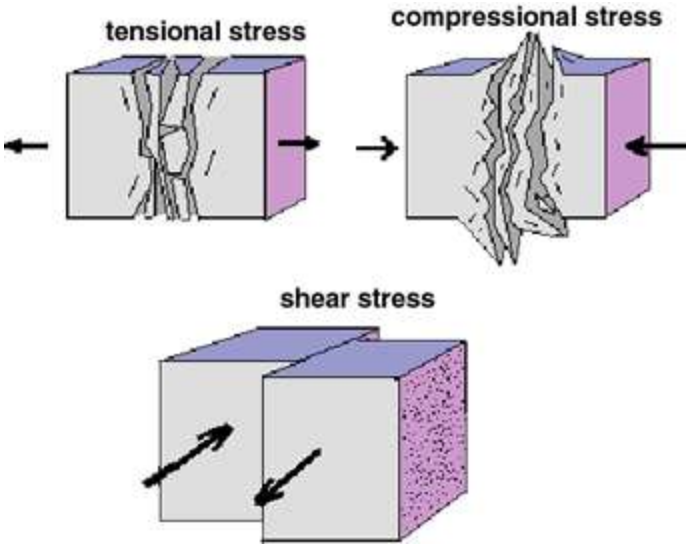
NORTH CAROLINA NCCAP CENTER for AFTERSCHOOL PROGRAMS
Public School Forum of North Carolina

STUDENT HANDOUT

MOUNTAINS TO THE SEA IN NC

DRIVING QUESTION: HOW DOES PLATE TECTONICS AFFECT NORTH CAROLINA?

Part 1: Candy Crush for Continents: Carefully unwrap the taffy. Get ready to "Stress out" your taffy by simulating the three main types of stress that deform the earth.
https://earthquake.usgs.gov/learn/glossary/images/stress_types.gif



1. **Compressional Stress**: Press the two ends of taffy together. Compression causes folding. In landforms, folding shows up as mountains and rolling hills. Compression formed mountains like the Himalayans and the Blue Ridge Mountains in NC. Note that the piece of candy got smaller when it was folded. This happened in NC when North American and Africa collided together, crunching and folding the continental crust and forming the Appalachian Mountains, of which the Blue Ridge is part. Mount Mitchell is the highest point of elevation in NC at 6484 feet. But our mountains may once have been as tall as the Himalayans, which are 29,000 feet. Where did our Mountains go? Wind, rain, and rivers eroded and carried away the mountains to form the sediments of our Coastal Plain.

Draw what your COMPRESSED taffy looks like.

2. **Shear Stress:** Hold one end of the taffy still and slide it past/move the other end away from it, so that it looks like an "S." Shear stress forms faults, like the San Andreas Fault. When you pulled the taffy sideways, parts of the candy got longer and thinner. In NC, as the Appalachian Mountains formed, chunks of land called terranes shifted and sheared off each other. They formed faults from earthquakes that we can still find in the Mountains near Brevard and in parts of the Piedmont. https://pubs.geoscienceworld.org/gsa/geology/article-abstract/16/10/915/204586/location-and-geometry-of-alleghanian-dispersal?redirectedFrom=PDF

Draw what your SHEARED taffy looks like.

STUDENT HANDOUT

3. **Tensional Stress:** Pull the taffy straight apart until it breaks. This tensional stress causes rifting or tearing. When magma and lava seeps up through the thinning, opening in the crust, then it cools to form brand new crust. In NC, the Atlantic Ocean is still rifting and tearing apart, which is moving us about 2 centimeters farther away from Europe and Africa each year. This is approximately the rate that a person's fingernails grow.
https://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Divergent/Mid-Atlantic-Ridge

Draw what your TENSIONED taffy looks like.

Part 2: Continent Races: Sometimes scientists have new ideas that seem extreme. Alfred Wegener noted that continents conveniently fit in puzzle-like shapes on maps. He considered additional evidence that continents themselves moved. He noted that fossils of the small mesosaurus lizards, which were not great swimmers, were found in both South America and Africa. Other evidence included similarities between mountains in the United States and Great Britain. There were also tropical plant fossils found in Antarctica. Wegener inferred that continents moved and called his theory "Continental Drift." Although his evidence supported that continents must move, nobody could explain exactly how it happened. Then, Harry Hess observed the Mid-Atlantic Ridge where the ocean floor was splitting apart like a zipper with new oceanic crust being formed. Hess called the concept Sea Floor Spreading. A combination of observations and ideas led to Plate Tectonic Theory.

Make a Model

1. Cut out the dark edges of the plate boundaries.
2. Pour about ½ inch of cold water with blue food coloring into a pie pan.
3. Place the map carefully on the center of the water's surface so that it is floating.
4. Add hot water with red food coloring on the edge of the pie plate.
5. Observe the convection currents and the continent movement.
6. Wait until the water stops moving (convection) and draw what you see.

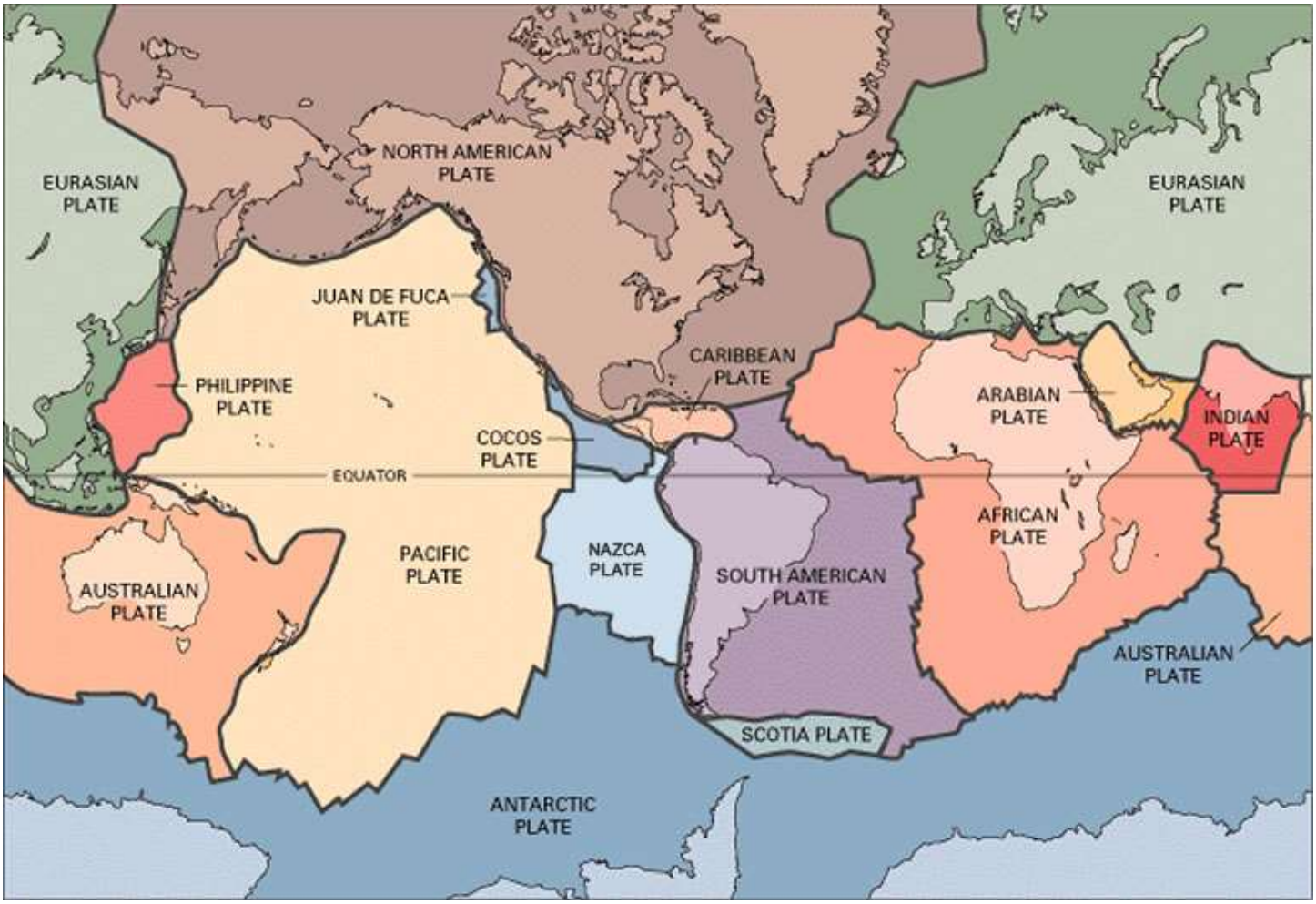
Before

After

STUDENT HANDOUT

Part 2: Continent Races

Cut along the bold lines, which are plate boundaries.



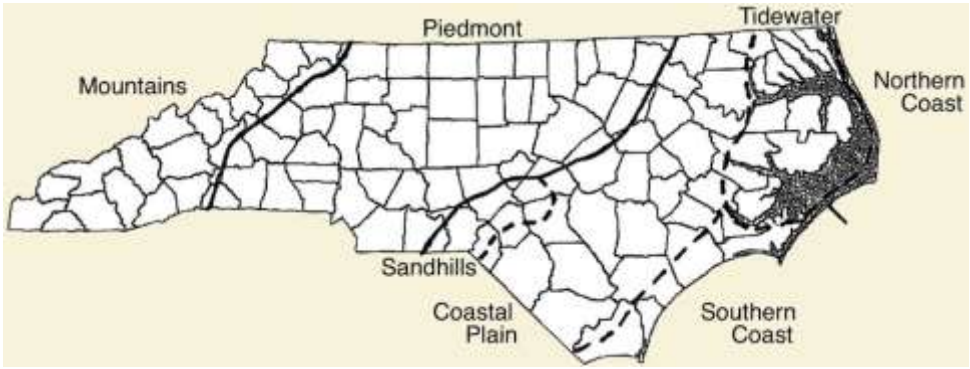
STUDENT HANDOUT

Part 3: Mountains to the Sea in NC (I-40)

DRIVING QUESTION: HOW DOES PLATE TECTONICS AFFECT NORTH CAROLINA?

North Carolina includes many landforms including mountains, ridges, hills, valleys, river basins, bogs, swamps, marshes, and estuaries. These landforms were made by plate tectonic processes that caused uplift of higher elevations, and weathering, erosion, and deposition in lower elevations. Many of these landforms are found in physiographic provinces: the Blue Ridge Mountains, Piedmont, and Coastal Plain which includes the Tidewater, which is impacted by the ocean.

Scientists determine risks that communities might encounter based on their geology. When people say, "geologic hazards", volcanoes and earthquakes come to mind. NC does not have any active volcanoes anymore. Although NC has occasional earthquakes, they do not tend to be very strong or frequent. Unfortunately, there are other geologic hazards that impact North Carolina that scientists and communities must plan for.

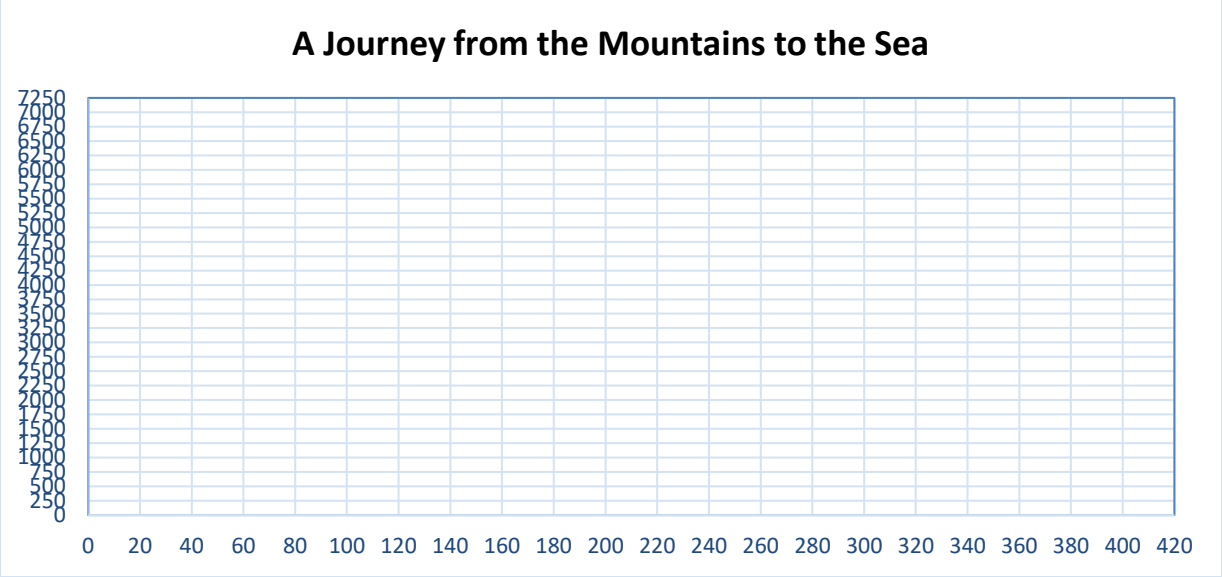


https://projects.ncsu.edu/cals/plantbiology/ncsc/EE/images/nc_map.jpg

Interstate 40 connects many cities and towns across NC. It also crosses NC's Physiographic Provinces. Let's graph a real journey to see how elevation changes as we drive from Mount Mitchell State Park to the ocean's edge at Wrightsville Beach. How might plate tectonics affect a community's potential geologic

Source: Google Maps Driving Directions

Towns	Distance	Elevation
Mount Mitchell State Park	0	6684
Marion	26.2	1404
Hickory	73.7	1188
Statesville	102.7	919
Winston-Salem	148.3	970
Greensboro	177.5	892
Chapel Hill	227.8	486
Raleigh	256	315
Clinton	321.3	157
Wilmington	392.9	30
Wrightsville Beach	398.9	7
Ocean	400	0



Data Analysis:

1. Describe how elevation changes as you drive from Mount Mitchell to the ocean's edge.

2. The Piedmont of North Carolina generally is 300 – 1500 feet in elevation above sea level. Use your graph to identify the breaks or boundaries between the physiographic provinces of Blue Ridge Mountains, Piedmont, and Coastal Plain. Draw a vertical line between the provinces and label them on the graph.

3. Which cites are in the Mountains?

4. Which cities are in the Piedmont?

5. Which are in the Coastal Plain? Of the cities in the Coastal Plain, which ones are in the Tidewater?

Think about it:

1. In the Southeastern United States, Europeans used rivers to explore the interior of the continent. As they paddled up the coastal plain, the sediments were being deposited, and the river bottoms were full of soft sediments. Rivers were wide, deep, and had many curves called meanders. Then, as the geology changed in the Piedmont, the rocks became resistant to erosion, and waterfalls showed up. When people got to the "Fall Line" they built mills and towns. Which of these mapped towns is located on the "Fall Line."

2. In North Carolina, the Coastal Plain is about 45%, and the Piedmont is also about 45%, with the remainder of the state's land in the Mountains. In what physiographic province do most of NC's people live today?

3. In 2018 and 2019, Interstate 40 was shut down from landslides and flooding. How would physiographic provinces impact geologic hazards? Use your graph to identify towns at risk from landslides. Which towns are at risk from flooding?

4. Asheville has an app for people to sue to determine the slope of their property. How might Asheville's location require them to make rules regarding what kinds of development people can build or use their property for?

5. Some scientists have calculated that sea level is rising 1 inch every two years. How many years will it take the Town of Wrightsville Beach to be underwater? How might hurricanes impact Coastal Communities?