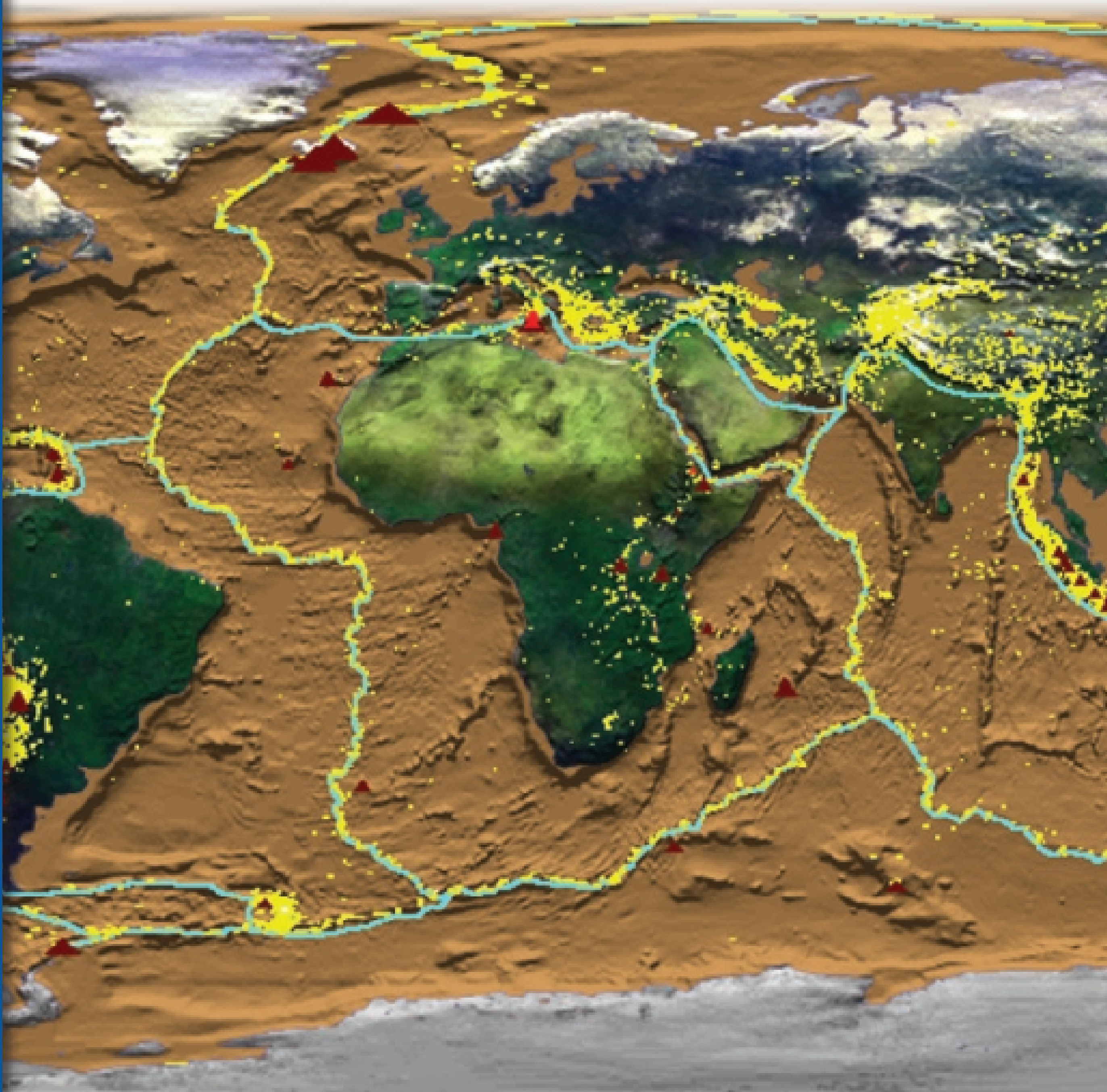
Unit 4

Plate Tectonics and Rock Cycling:

What causes Earth's surface to change?

Student Work Pages



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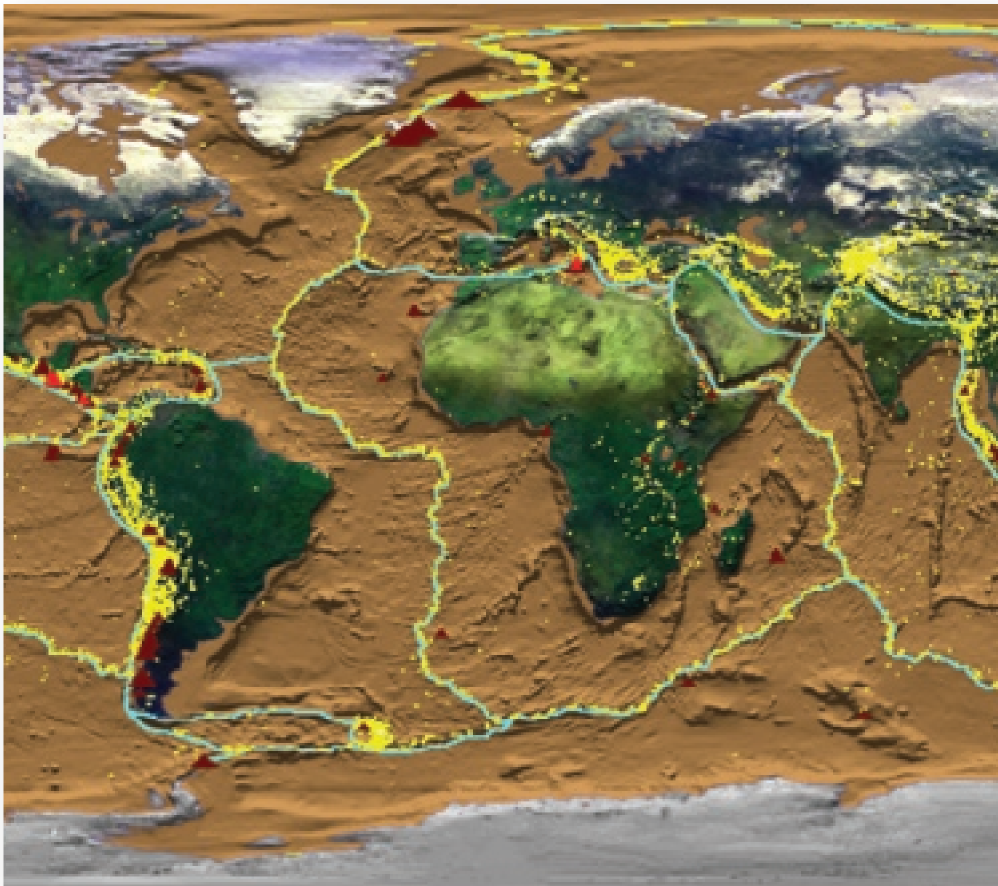

Plate Tectonics and Rock Cycling:

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Student Work Pages

Core Knowledge Science

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Plate Tectonics and Rock Cycling:

What causes Earth's surface to change?

Table of Contents

Science Literacy Exercise Pages

Name: ______________________ Date: ______________

Explain how Mt. Everest moves and grows.

In the box below, draw an initial model to try to explain the following:

- What might cause Mt. Everest to increase 2 cm each year?
- What might cause Mt. Everest to move to the northeast 4 cm each year?

Use words, pictures, and anything else to help capture your thinking.

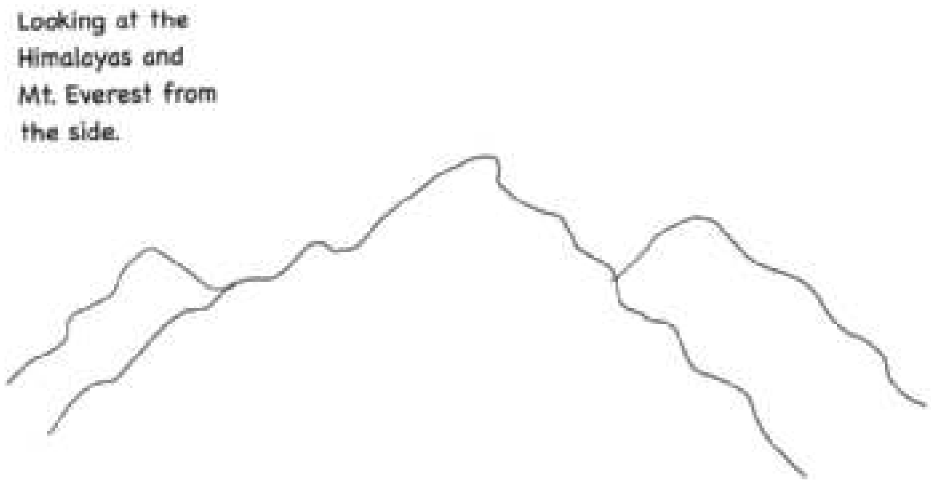
Use your model to explain:

How Mt. Everest moves 4 cm to the NE each year	How Mt. Everest grows taller by 2 cm each year

Name: ______________________________ Date: ______________________

Alternate: Initial Model

Based on what you have figured out about how Mt. Everest is changing over time, use the image below to represent the changes happening to Mt. Everest.



Name: ______________________________ Date: ______________________

Patterns of Change for Mountains

Data for Causing Growth	Data for Causing Decrease in Height

Patterns Between Mountains

Name: ______________________ Date: ______________________

Explaining Other Mountains That Shrink

In the spaces below, draw an initial model to explain what might be occurring with other mountains.

Explaining a shrinking mountain
• Choose a location where the data shows that the mountain has been decreasing in elevation. • Develop a model to represent what you think is causing this to happen to the mountain.

Use your model to explain:

How a mountain shrinks over time

Name: ______________________ Date: ______________

Circle the question you will be researching:

- How is Earthquake Depth Related to Where Mountains Are Moving?
- How is Earthquake Strength (Magnitude) Related to Where Mountains Are Moving?
- How is Earthquake Depth Related to Where Mountains Are Growing?
- How is Earthquake Strength (Magnitude) Related to Where Mountains Are Growing?

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Name: ______________________ Date: ______________________

How are earthquakes related to where mountains are located?

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Name: ______________________ Date: ______________

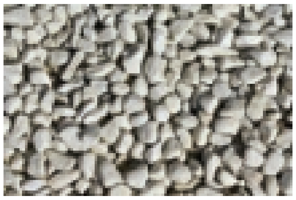
What do we see on Earth's surface where we live?

When we look around at the places where we live, one of the first things we might notice about Earth's surface could be examples of structures that people have created to help them do things, such as buildings, roads, and farms. These examples characterize the part of Earth's surface that we encounter every day.

If we look around to find places where there are no structures on the surface, we sometimes find plants growing on the surface. But what is Earth's surface like underneath all of these? If we could remove all these structures and all of these plants in all of these locations, what are some different things we would find? Record your ideas below:

____

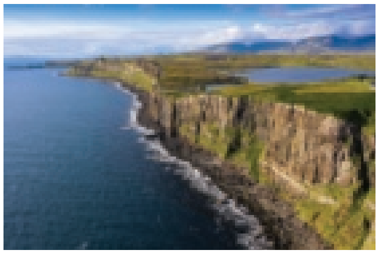
____



While some places are covered with thick layers of soil, plants, and forests, other locations have huge pieces of rock visible at the surface, such as mountains and cliffs. Many of the places that people live and work have been modified significantly with things that are not necessarily natural to the land, such as adding grass or cement. But most of Earth's surface (70%) is covered by oceans. Probably the most striking thing is just how varied Earth's surface really is.

In many places, the surface of Earth is often covered in loose pieces of material or sediment, such as dirt, sand, or gravel.

In other places, larger pieces of solid rock are exposed, or sticking out of the surface, such as in many rock cliffs or mountain sides, like shown in the photos below.



Use the space below to describe some of these natural materials you see on the surface in the area that you live. Next time you meet with your class, be ready to share the natural materials you found in the area that you live.

Describe some of the things that you notice on Earth's surface near your home or school.

____

____

____

Name: ______________________ Date: ________________

Materials Found at and Below the Surface

Site	Data source(s)	Materials at the surface	Materials below the surface
Digging and Drilling Underground			
Mt. Everest and the Himalayan Mountains			
Mt. Aconcagua and the Andes Mountains			
Mt. Mitchell and the Appalachian Mountains			
Mt. Hotaka and the Hilda Mountains			
Mt. Narodnaya and the Ural Mountains			

Name: ______________________ Date: ______________

Reading: What do people dig or drill deep underground for and what do they find?

Mines and quarries are places where people dig into Earth's bedrock to extract valuable materials. For thousands of years, people around the world have mined, quarried, or drilled into Earth to get resources found below the surface. These resources include minerals, like copper, iron, gold, or diamonds. People also look for energy resources, like coal, oil, or natural gas. Other times they drill for access to fresh water (groundwater). Today, advanced technology has allowed people to develop mines that go deeper beneath Earth's surface than ever before.

 Underground mine	 Rock quarry (open-pit mine)
 Oil pump	 Water pump

In the mining video, you saw how drilling is used to get a sample of the material found at different locations and at different depths. Once scientists find something of interest, they will dig a larger tunnel to create a mine. The samples you saw in the video showed materials that could be found in different layers at a particular location.

Humans have drilled into mountains, grasslands, arctic areas, swamps, lakes, islands, the ocean bottom, deserts, and many other areas. Everywhere that this has been done, people always hit solid rock at some point below the surface (or right at the surface). Many of the resources that people are mining or drilling for are found in gaps or layers within this solid rock. These are often referred to as **deposits**.

The solid rock is often referred to as **bedrock**. Bedrock can include a number of different types of rock. One type of rock that bedrock is made of is called sedimentary rock. This type of rock is made when any small pieces of material (sediment), such as sand or small pieces of rock, shells or dirt, is compressed over time until they form a single piece of solid rock. Some examples of sedimentary types of rock are limestone and sandstone. These types of rocks are often found in bedrock. When sedimentary rock is deep underground, the heat and pressure causes changes to the rock. For example, marble forms from limestone that has experienced lots of heat and pressure. Another type of rock that bedrock can be made of is volcanic, or igneous rock. Examples of volcanic rock include granite and basalt.

Absolute depth to bedrock (cm)

As people dig further and further down under the surface, the temperature increases and the bedrock gets hotter. The temperature of bedrock increases, or goes up, about 72° F per mile down (or about 1.4° F per hundred feet). The deepest mine in the world is the Mponeng Gold Mine. It goes down 12,600 feet (nearly 2.4 miles) below the surface of Earth. Temperatures in this deep mine can get over 300 °F. One way engineers cool the air and surrounding rock is by pumping cold water into the mine, so that people can survive working in these mines.

Think about and respond to the following questions:

1. At the end of class, you made a prediction about whether you would find solid rock (bedrock) below the surface where we live. Would you revise that initial prediction now? Why or why not?

____

____

____

2. What new ideas do you have about the structure of the rock deep underground?

____

____

____

3. How could you use what you learned to explain why some mountains grow or move? What new questions do you have now?

____

____

____

Name: ____________________ Date: ____________

Rock Investigations Data Chart

Investigation A

Part 1

Observations

- Take these two rock samples out of the bin. Feel each rock, try to scratch each with your fingernail, and rub the two rocks against one another.
- Next, look closely with the hand lens.
- Use pictures, words, and/or symbols to document your observations in the spaces below.

Sample A: Sandstone	Sample B: Limestone

Questions

1. How are these two rocks similar? How are they different?

Similarities	Differences

2. Look back at the mountain case cards and find the sites where these rocks are found. Why might they be found in these locations?

Part 2

Observations

- Pick up these two different types of rocks from the bin. Feel each rock, try to scratch each with your fingernail, and rub them against one another.
- Use the hand lens to take a close look at each sample.
- Use pictures, words, and/or symbols to document your observations in the spaces below.

Sample C: Granite	Sample D: Basalt

Part 3

Questions

1. What does it mean that basalt is more dense than granite?

2. Why do you think that a more dense type of rock tends to be found in the bedrock below the ocean than what tends to be found on land?

Investigation B

Part 1

Questions

1. In the image in **Part 1** of **Investigation B**, what is happening to the rock sample as it is compressed?

2. What do you think would need to happen in order for the rock sample to creep? *(**NOTE:** You may want to revisit this question after you complete Part 2.)*

Part 2

Observations

As you complete the steps outlined in **Part 2** of **Investigation B** for each sample of clay, document your observations using pictures, words, and/or symbols.

Room Temperature Ball of Clay

Cold Ball of Clay

Warm Ball of Clay

Questions

1. Do each of the clay samples change in the same way? Why do you think this happens?

2. What do you think would happen if we added more pressure by pressing down on the brick or if we added additional bricks on top?

Part 3

Questions

1. Why do you think the tools that the scientists were using to drill the hole were misshapen?

2. What did the scientists learn from this experience?

3. What do you think the scientists could have done so that they could continue to drill? *(**NOTE:** You may want to revisit this question after you complete Investigation C.)*

Investigation C

Part 1

Observations

Analyze the data in the table to the right. Document any patterns or interesting relationships you notice about the materials and their melting points.

Type of rock or mineral	Melting point
Sand	1550°C
Sandstone	1500°C
Limestone	825°C
Granite	1260°C
Iron	1538°C
Copper	1084°C
Gold	1064°C
Table salt	801°C

Questions

1. Why would glass artists and blacksmiths need to heat up the materials they work with?

2. What happens to these materials after they are heated?

Part 2

Questions

1. What do you notice about the sample of sand when you look at it and feel it?

2. What kinds of tools do glass blowers and blacksmiths use to work with their materials?

3. What kinds of safety precautions do they take when working with their materials?

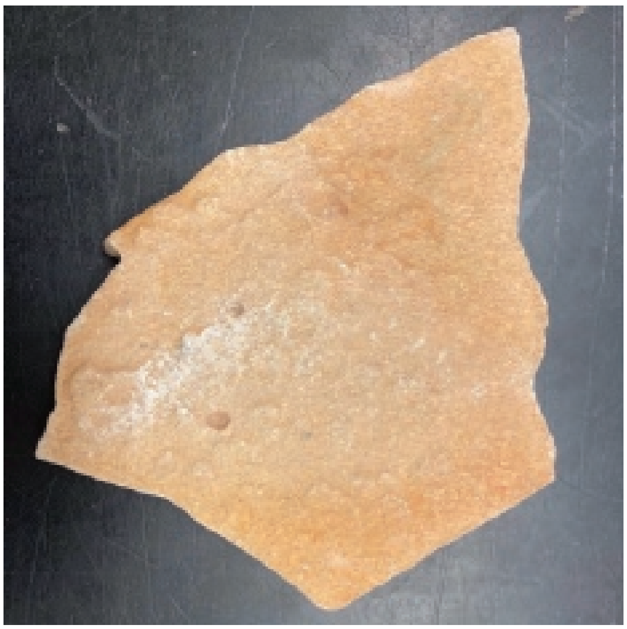
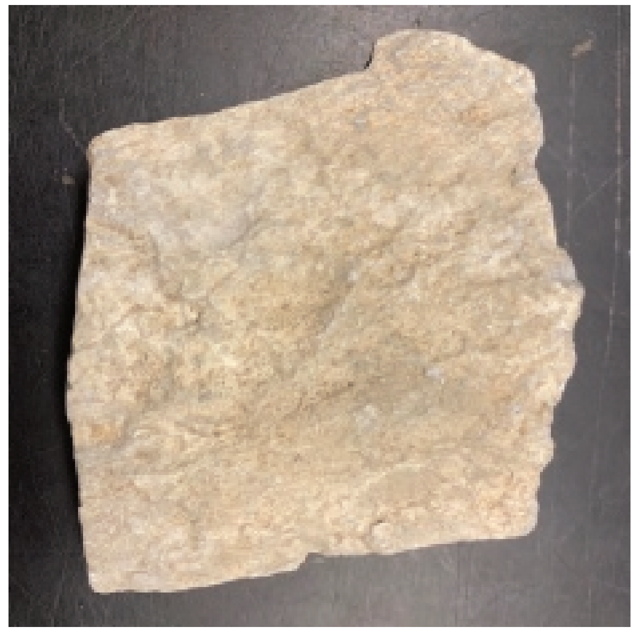
Investigation A

Part 1

In your investigation bin, find two rock samples: sandstone and limestone.

<u>Observations</u>

- Take these two rock samples out of the bin. Feel each rock, try to scratch each with your fingernail, and rub the two rocks against one another. Document your observations.
- Next, look closely with the hand lens and record what you see.

Sample A: Sandstone	Sample B: Limestone
	
Sandstone is formed from sand when it is compressed by very strong forces, such as when buried under a large weight of material above it.	*Limestone is formed from shells of small marine animals that have been compressed by very strong forces, such as when buried under a large weight of material above it.*

<u>Questions</u>

1. How are these two rocks similar? How are they different?
2. Look back at the mountain case cards and find the sites where these rocks are found. Why might they be found in these locations?

Part 2

One interesting pattern that miners, scientists, and engineers have noticed is that when digging or drilling down deep on land, the most common type of solid rock that they encounter is ***granite,*** while the most common type of solid rock they encounter when drilling down on the ocean floor is ***basalt.***

Observations

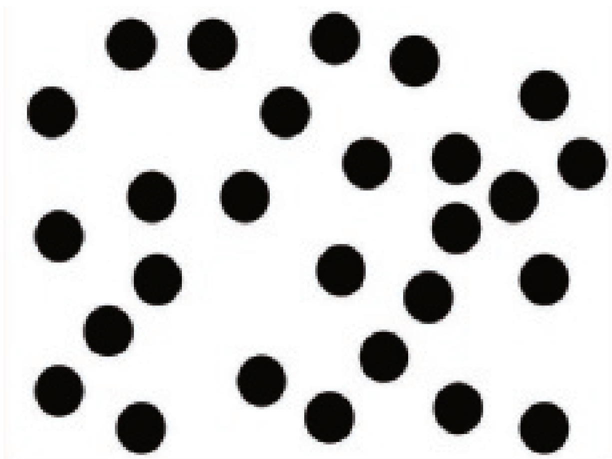
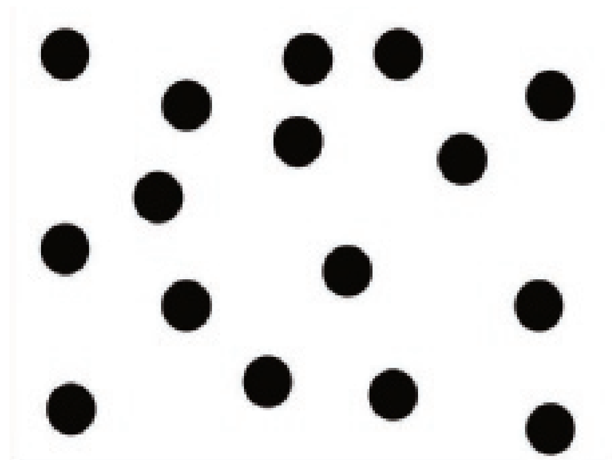
- Pick up these two different types of rocks from the bin. Feel each rock, try to scratch each with your fingernail, and rub them against one another. Document your observations.
- Use the hand lens to take a close look at each sample and document your observations.

Sample C: Granite	Sample D: Basalt
	

Part 3

Granite and basalt have different densities. Basalt is a bit more dense than granite. Think back to what you figured out related to air masses or parcels of air in your prior work around density in *Storms Unit*.

Remember, density is the relationship between the amount of matter (mass) in a sample and the amount of space it takes up (volume). In other words, the more tightly packed the particles of matter are in a given amount of space, the more dense that matter is.

Sample X	Sample Y
	
***Sample X** has more particles of matter packed into the given space. It is **more dense** than **Sample Y**.*	***Sample Y** has fewer particles of matter packed into the given space. It is **less dense** than **Sample X.***

<u>Questions</u>

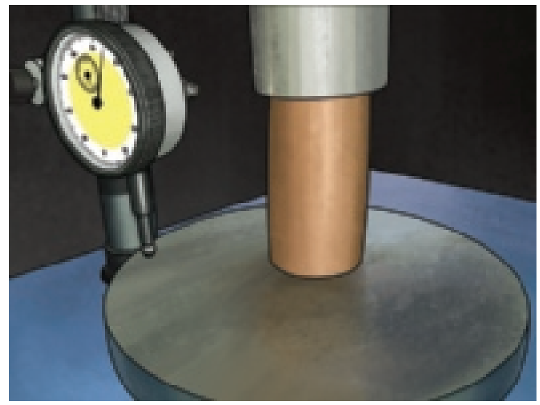
1. What does it mean that basalt is more dense than granite?
2. Why do you think that a more dense type of rock tends to be found in the bedrock below the ocean than what tends to be found on land?

Investigation B

Part 1

You have heard that a challenge engineers face in digging deeper mines is the increase in temperature they encounter. Another challenge that comes with this is the effect higher temperatures have on the behavior of rocks and minerals deep below the surface. As rocks warm up, they become softer and move or flow. The warmer they are, the more rock moves and flows. And because there is more and more weight on top of rocks the further down you dig, this additional weight compresses (or squeezes) these rocks with more and more force (or pressure).

The combination of higher temperature and compression of the rock can cause it to creep very slowly. **Creep** is a gradual shape change of the rock. Engineers can test rock samples in the lab to see how much they creep by compressing them under different amounts of weight at different temperatures. An image of such a test is shown to the right.

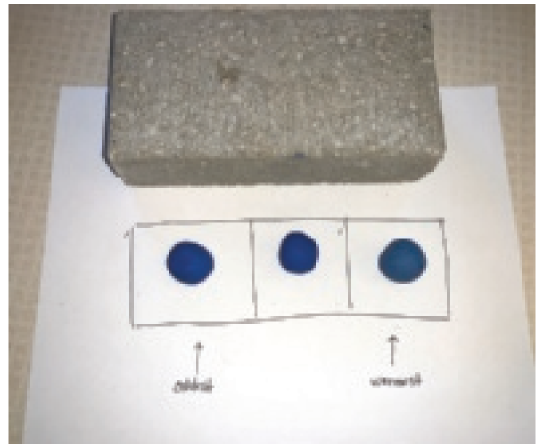


Questions

1. In the image above, what is happening to the rock sample as it is compressed?
2. What do you think would need to happen in order for the rock sample to creep? (***NOTE:*** *You may want to revisit this question after you complete Part 2.)*

Part 2

Clay is a type of solid material found in some places below the ground. You will use modeling clay that has characteristics similar to the clay that is found in the ground to carry out a compression test to observe how the behavior of a solid can change with temperature.



<u>Observations</u>

As you complete the following steps for each sample of clay, document your observations.

A. Place a brick on a piece of paper on the table. Mark 3 squares to place 3 samples of clay at different temperatures. Label the location of the coolest sample and the warmest sample.

B. Begin with the room temperature sample of clay. *Do not get the cold or warm samples until you need them.*

C. Place the sample of the clay so that its edge lines up with the edge of the brick.

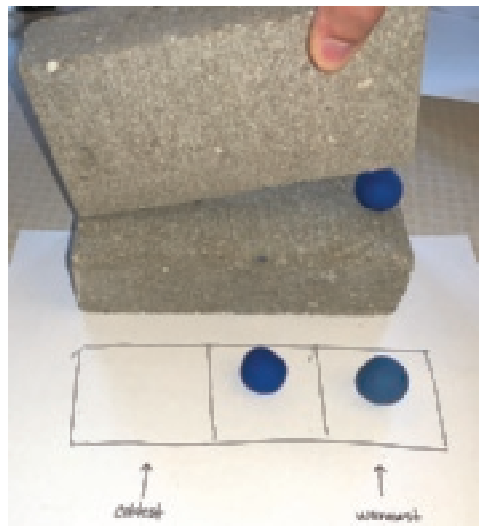
D. Take a 2nd brick and rest one edge of it against the 1st brick below it, tilting it up with your hand so that this 2nd brick isn't touching the clay sample yet.

E. Then slowly lower the brick down until it is resting on the clay sample.

F. Observe the behavior of the clay over the next 30 seconds.

G. Lift the brick up and place the sample on its corresponding place on the paper.

H. Repeat steps C-G for each of the remaining samples of clay. *Collect only one of the remaining samples at a time. It is important that the cold and warm samples of clay do not change in temperature before you use them.*



<u>Questions</u>

1. Do each of the clay samples change in the same way? Why do you think this happens?
2. What do you think would happen if we added more pressure by pressing down on the brick or if we added additional bricks on top?

Part 3

The deepest hole ever dug was started in the 1970s, in the Arctic Circle by scientists who were interested in figuring out more about Earth below the surface. The hole they dug reached a depth of 40,230 feet (7.6 miles) below the surface by 1994. At this depth, the temperature of the rock reached 356°F (180°C) at which point the drill began to encounter problems. The rock began to soften so much that it became harder to drill into. Every time the drill bit was taken out, it required maintenance or replacement because the drill bit had been misshapen or deformed. In addition, when drilling stopped, the rock at the bottom of the hole would creep in to fill up a portion of the hole, and it had to be re-drilled again.

<u>Questions</u>

1. Why do you think the tools that the scientists were using to drill the hole were misshapen?
2. What did the scientists learn from this experience?
3. What do you think the scientists could have done so that they could continue to drill? *(**NOTE:** You may want to revisit this question after you complete Investigation C.)*

Investigation C

Part 1

Rocks can melt when they reach a high enough temperature. A list of the melting points of some different types of rocks and minerals is shown to the right.

As rocks warm up they begin to soften. This softening of the rock happens at temperatures below the melting point of the materials that make them up.

As this happens, rocks are easier to deform (bend or change shape) when a force is applied to them. This means material they are made of moves and responds to pushes and pulls more easily. You can see this change in behavior as you heat up sand to its melting point and then let it cool it back down. This is how glass is sculpted into different shapes by artists. You also see this change in iron when heated close to its melting point. This is how blacksmiths sculpt iron.

Type of rock or mineral	Melting point
Sand	1550°C
Sandstone	1500°C
Limestone	825°C
Granite	1260°C
Iron	1538°C
Copper	1084°C
Gold	1064°C
Table salt	801°C

Observations

Analyze the data in the table above. Document any patterns or interesting relationships you notice about the materials and their melting points.

Questions

1. Why would glass artists and blacksmiths need to heat up the materials they work with?
2. What happens to these materials after they are heated?

Part 2

Find the sample of sand in your bin and feel it. Then, use a hand lens to examine it closely. Examine the images below and watch the following video :

- https://youtu.be/c7-GBrqOwpg

Sand being melted at a high temperature to make glass

A blacksmith sculpting heated iron on an anvil with a hammer

Questions

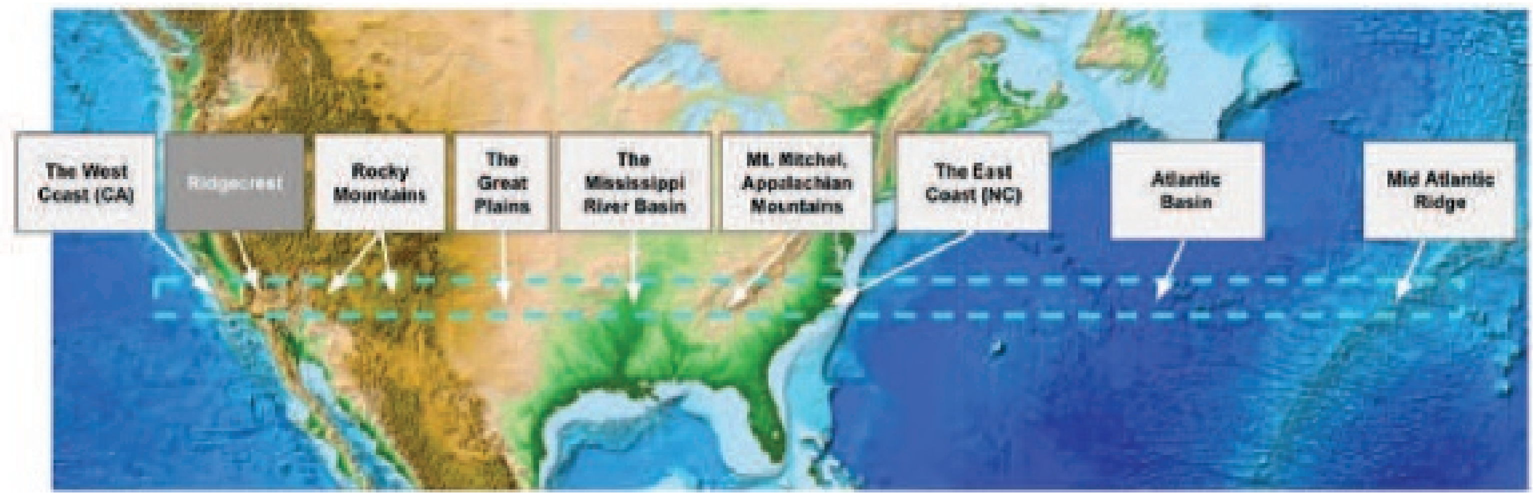
1. What do you notice about the sample of sand when you look at it and feel it?
2. What kinds of tools do glass blowers and blacksmiths use to work with their materials?
3. What kinds of safety precautions do they take when working with their materials?

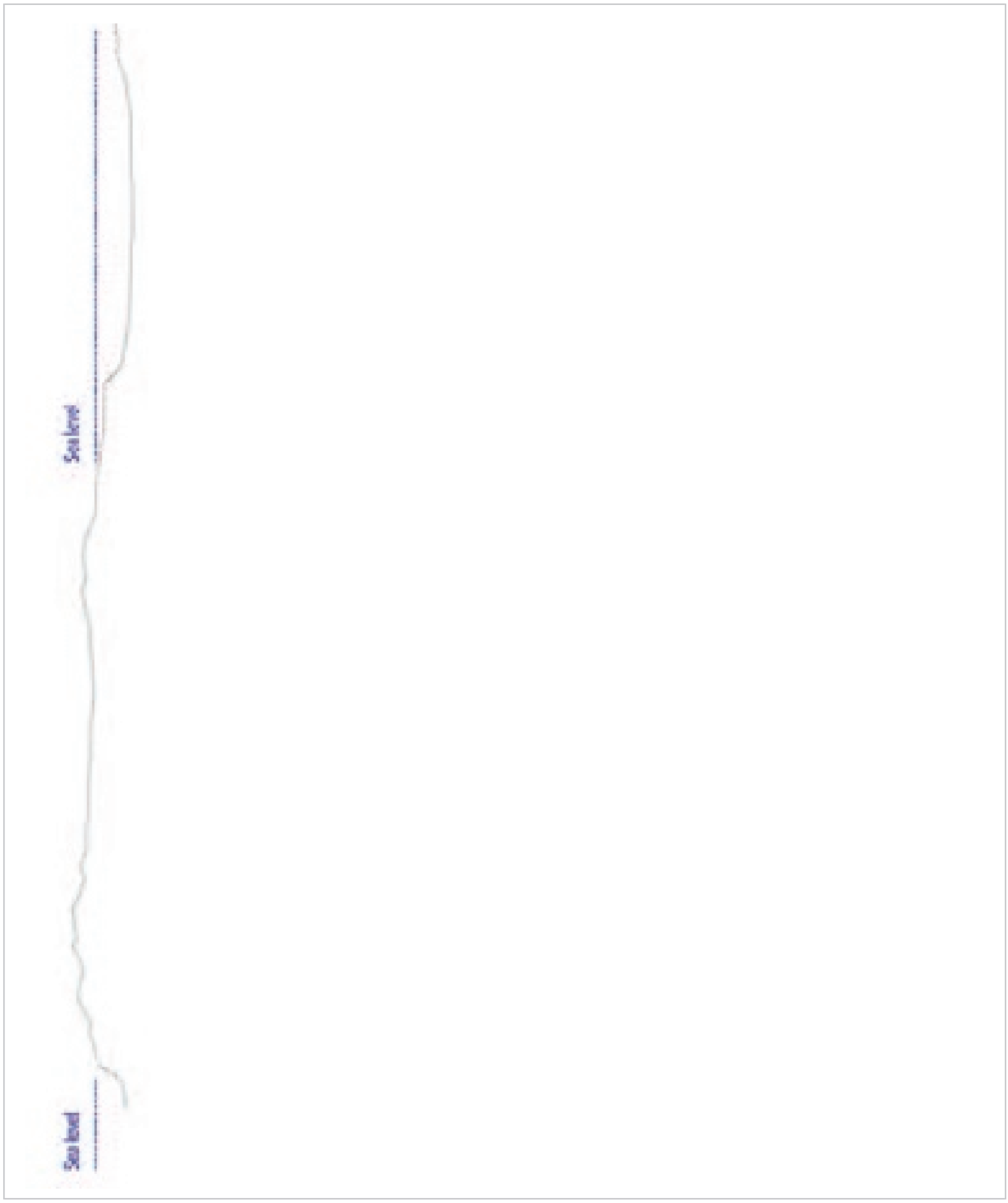
Name: ______________________ Date: ______________________

Constructing Profile Model West and East of Ridgecrest

With your small group, use the space below to develop a cross section model representing the different elevation of the land from west of Ridgecrest all the way to the middle of the Atlantic Ocean. Your model should include:

- the regions we discussed
- the depth of the ocean
- where sea level is (the shore, where the ocean meets the land)
- use the appropriate scale
- what you think is on the surface
- what you think is underneath the ground level you've shown

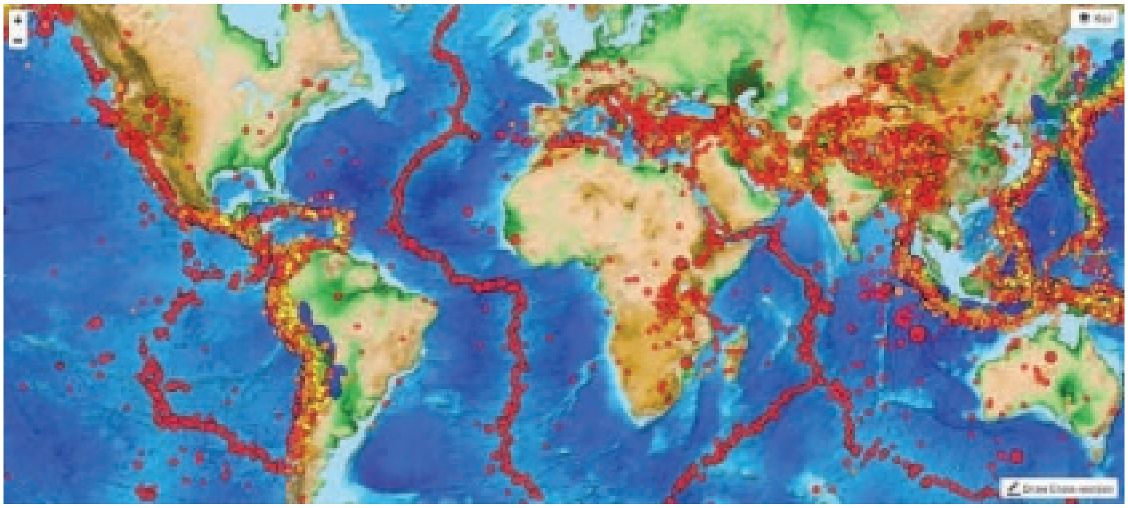



Sea level
Sea level

10-Year and 30-Year Earthquake Data

10 years of earthquake data

30 years of earthquake data



Name: ______________________________ Date: ______________________

North American Plate Manipulative

Cut out the smaller image of the North American Plate. Place it on the larger image of the World Map to show where you predict the North American Plate will be located many years into the future.

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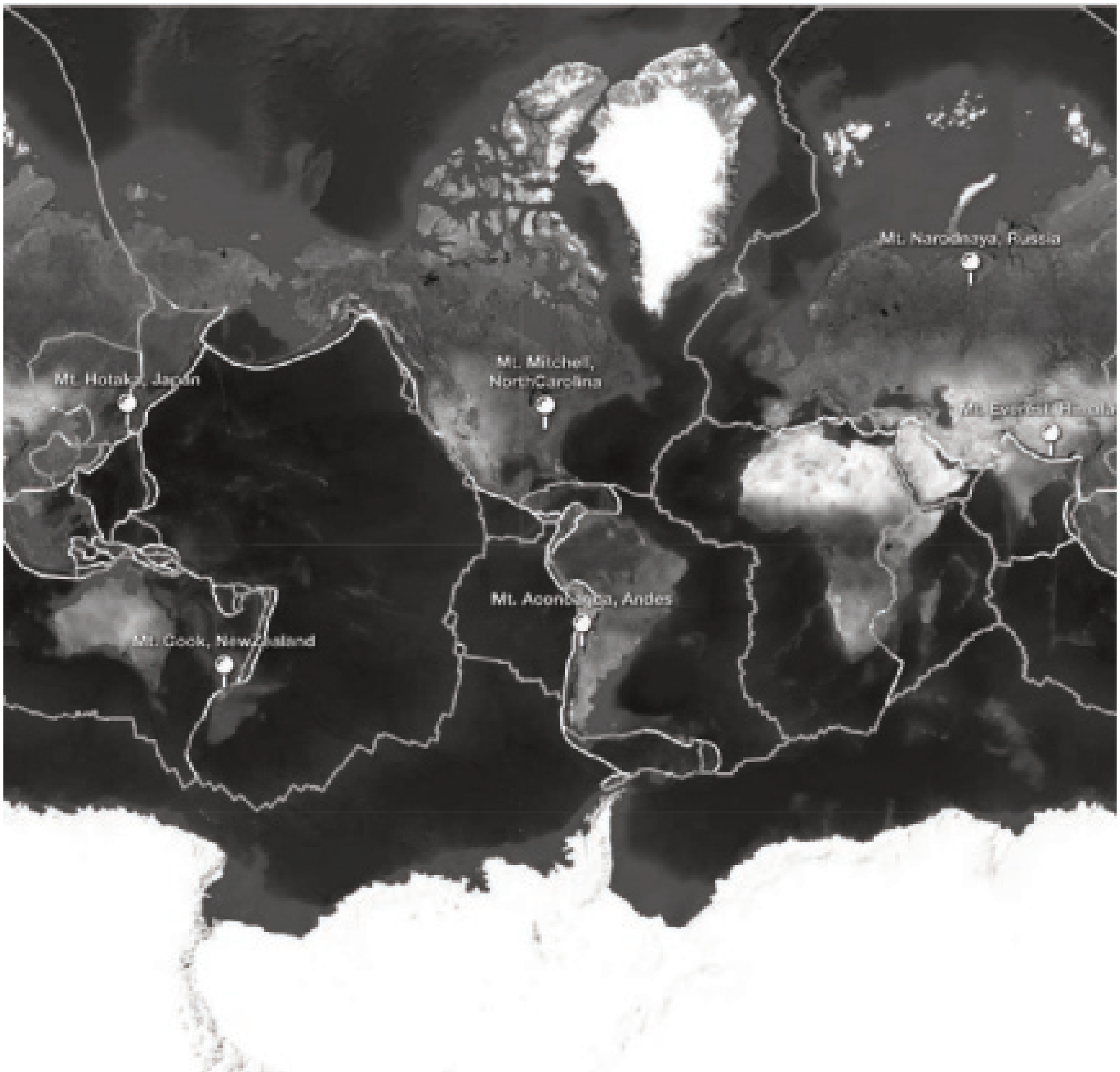
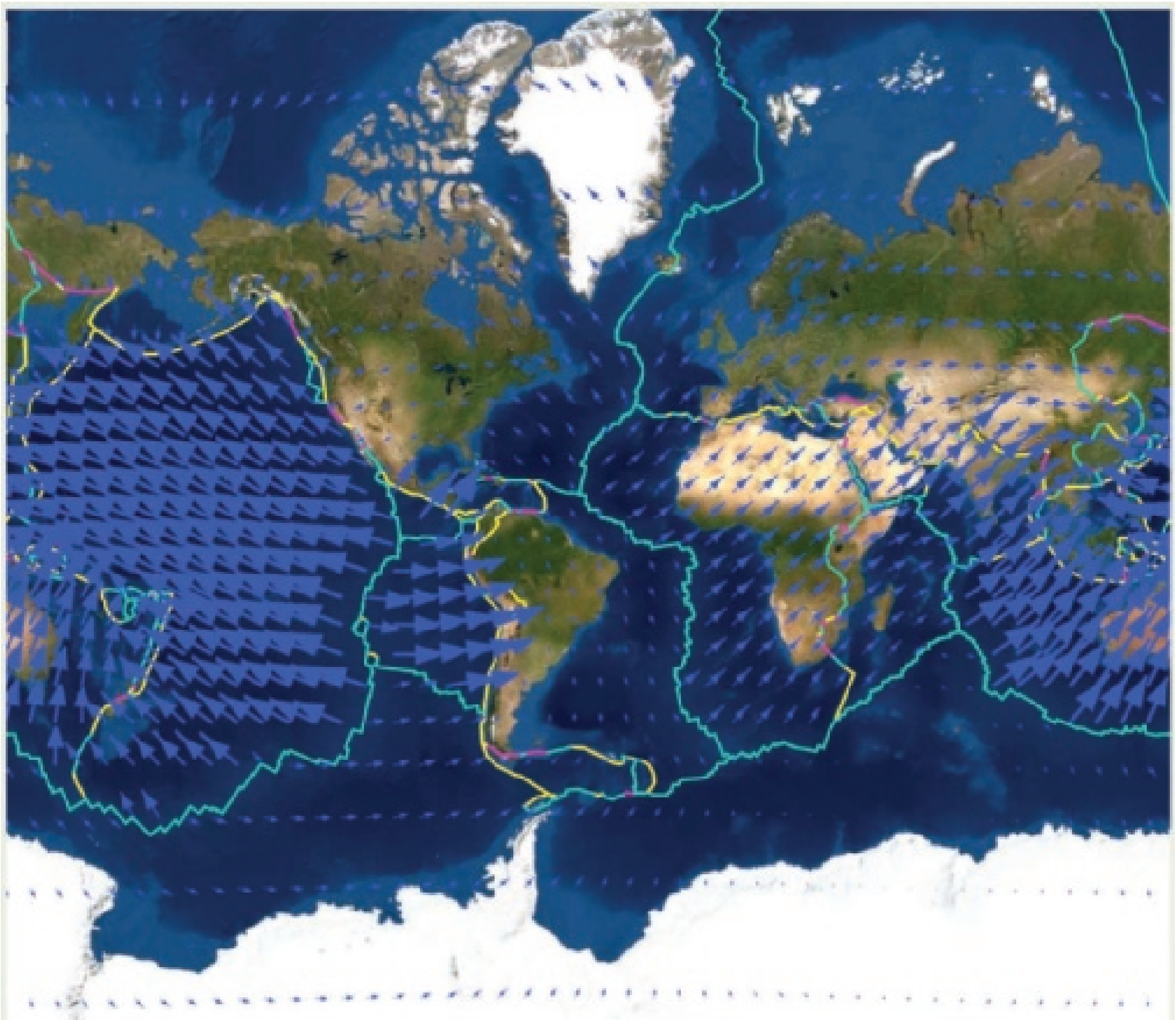
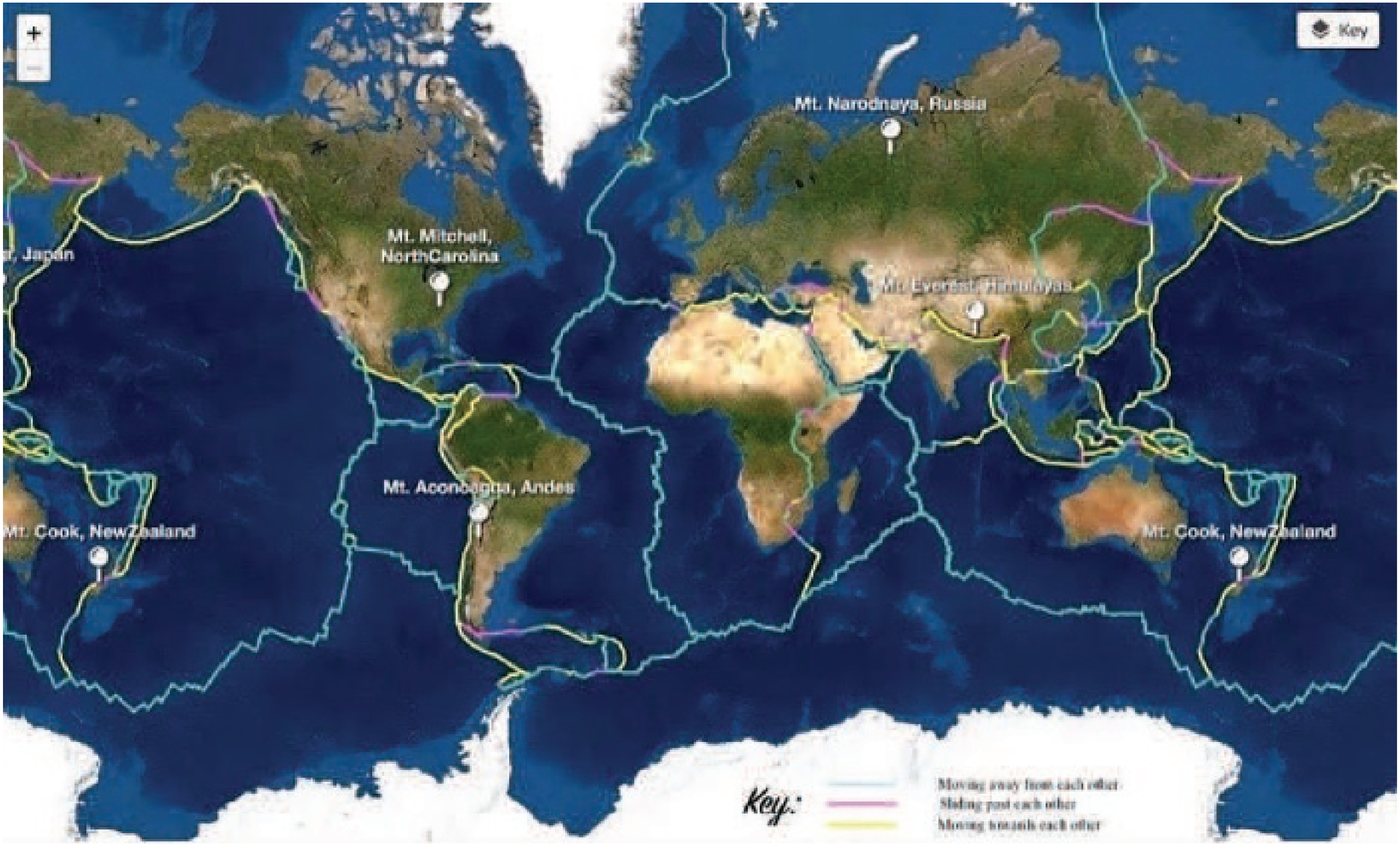

Mt. Narodnaya, Russia
Mt. Mitchell, NorthCarolina
Mt. Hotaka, Japan
Mt. Cook, New Zealand

Name: ______________________ Date: ________________

Plate Movement Maps




Key
Mt. Narodnaya, Russia
Mt. Mitchell,
NorthCarolina
Mt. Everest, Himalayas
Mt. Aconcagua, Andes
Mt. Cook, NewZealand
Mt. Cook, NewZealand
Key:
Moving away from each other
Sliding past each other
Moving towards each other

Name: ______________________________ Date: ______________________


North American Plate
Eurasian Plate
African Plate
Indian Plate
South American Plate
Australian Plate

Name: ______________________________ Date: ______________________

Record Your Observations

My group's rock types: ______________________________ & ______________________________

Type of movement of the plates: Moving toward each other

One location where you see this type of interaction happening on your world map for your rock types:

____

How did the plates themselves change? Was one different from the other or did the same thing happen to both?
What happened to the softer, warmer (liquidy) rock (mantle)?
What happened along the edges of the plates as the plates moved?
What else did you observe?

My group's rock types: ______________________________ & ______________________________

Type of movement of the plates: Moving away from each other

One location where you see this type of interaction happening on your world map for your rock types:

____

How did the plates themselves change? Was one different from the other or did the same thing happen to both?
What happened to the softer, warmer (liquidy) rock (mantle)?
What happened along the edges of the plates as the plates moved?
What else did you observe?

My group's rock types: ______________________ & ______________________

Type of movement of the plates: Sliding past each other One location where you see this type of interaction happening on your world map for your rock types:

____

How did the plates themselves change? Was one different from the other or did the same thing happen to both?
What happened to the softer, warmer (liquidy) rock (mantle)?
What happened along the edges of the plates as the plates moved?
What else did you observe?

Name: ____________________ Date: ____________

Volcano and Earthquake Data Chart

Site	Types of Changes (yearly)		Event (yes or no)		Are the changes to the mountain caused by volcanoes?
	Location	Elevation	Volcanoes	Earthquakes	
Mt. Everest in the Himalayan Mountains					
Mt. Mitchell in the Appalachian Mountains					
Mt. Aoraki in the Southern Alps					
Mt. Aconcagua in the Andes Mountains					
Mt. Hotaka in the Hilda Mountains					
Mt. Narodnaya in the Ural Mountains					

Reading: How are volcanoes formed and what kinds of changes do they cause?

Where are volcanoes found?

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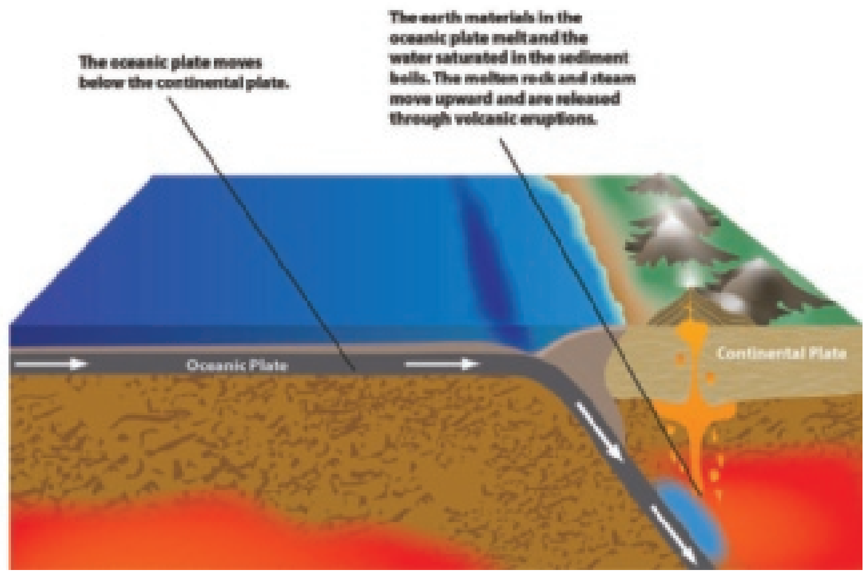
A volcano is an opening in Earth's crust that allows melted rock, rock debris, gases, and steam from deep within Earth to pour or shoot out. Volcanoes are located on every continent, and there are about 1,500 volcanoes considered potentially active around the world. They are usually found in lines along or near coastlines of continents. Most volcanoes are formed close to the boundaries, or edges, between a denser oceanic plate and a less dense continental plate.

How are volcanoes formed?



Oceanic plates are made up of bedrock with a thin layer of water-soaked sediments on the surface. When the denser oceanic plate collides with the less dense continental plate, the oceanic plate moves under the continental plate and into the mantle below Earth's crust. The heat of the mantle causes the bedrock and sediment to melt while the water boils. The melted rock, or magma, along with the trapped steam push upward near the edge of the continental plate and make their way through large openings in Earth's crust. These openings—or volcanoes—are very deep and extend from the surface, through the continental plate, and to the mantle. Over many years, the cooled, solidified earth materials that are pushed through the openings in the crust build up and become cone-shaped volcanoes.

What kinds of changes do volcanoes cause to the surface of Earth?

Volcanoes cause changes to the surface of Earth either through **destructive** processes or **constructive** processes. **Destructive** means to cause damage or break down, while **constructive** means to build up.

Destructive processes break down land and rocks and scatter these materials. When you picture a volcano you probably picture lava, ash, and gas exploding out of Earth. When volcanoes erupt in explosive ways, they can blow the top off of a mountain and scatter rocks, soil, and other earth materials over a large area. An example of this was the 1980 eruption of Mount St. Helens in Washington. Beginning in March of 1980, a series of earthquakes over a two-month period of time was evidence that the volcano was once again active. On May 18, a 5.1 magnitude earthquake caused the entire north face of the mountain to slide away, causing the largest landslide in recorded history. This triggered a volcanic eruption that blasted ash 80,000 ft. in the air! Over time, that ash was scattered across 11 states and portions of Canada. The combination of the landslide and the violent eruption displaced so much earth material that the height of Mount St. Helens decreased by 1,314 feet.

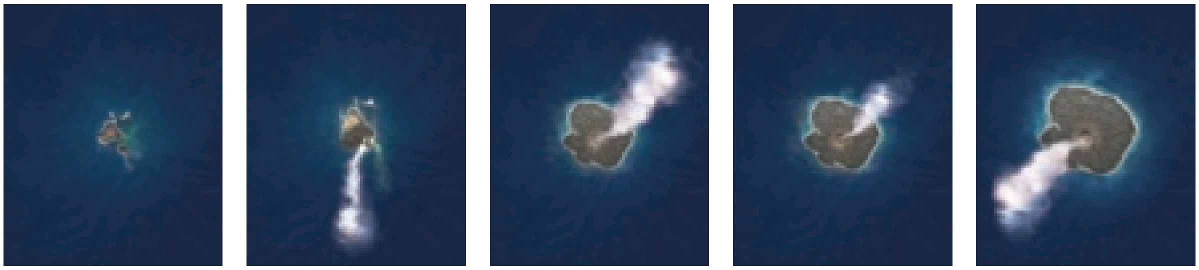
Constructive processes lead to the creation of new land. When volcanoes erupt in constructive ways, melted rock, or lava, flows out over the land, and cools. This creates new earth material. Over time, the volcano can increase in height and eventually become a mountain. An example of this type of constructive process is seen happening over an 8-year period of time with the volcanic eruption at Nishinoshima. Nishinoshima is a volcanic island located almost 600 miles south-southeast of Tokyo, Japan. It is one of many islands located near Japan.

Mount St. Helens one day before the eruption.

Mount St. Helens four months after the eruption.

Nishinoshima in 2018

Nishinoshima Island 2013–2021



September 2013 | April 2014 | March 2018 | June 2018 | August 2021

NASA's Earth Observatory

The picture above shows satellite images of Nishinoshima from September 2013-August 2021. Only a small part on the western side of the island remains unburied. Smoke can be seen coming from the volcano in several of the images.

Seismic Explorer Plate Movement Map

Name: ______________________________ Date: ______________________

Evidence Tracker

Before we analyze artifacts from the ridge and collect evidence, re-write your claim from your exit ticket here:

____

____

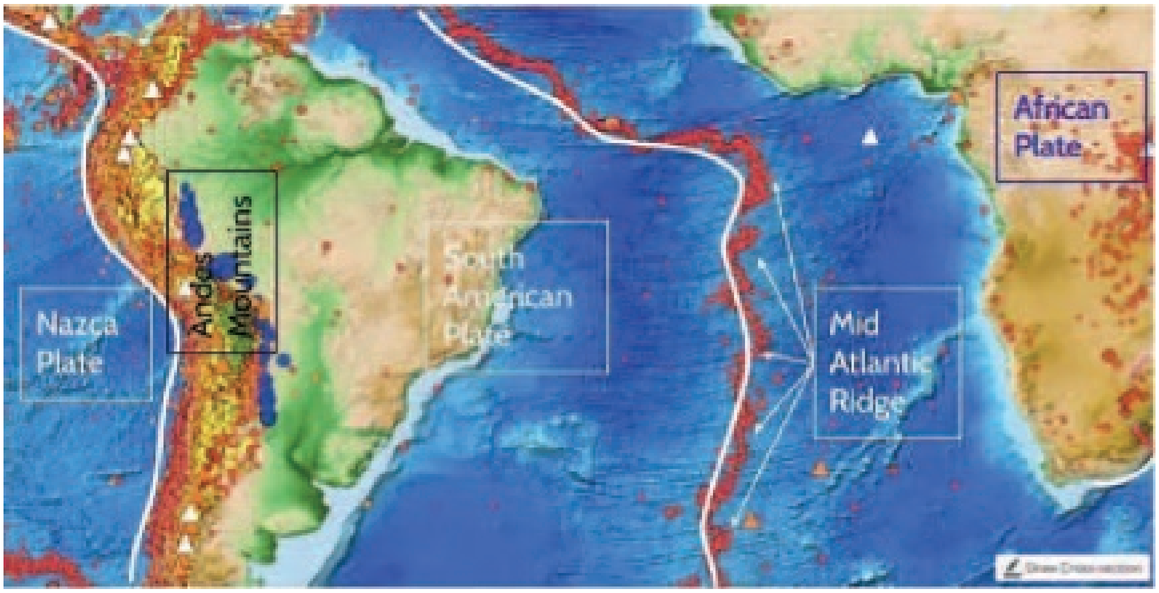
Use the table below to keep track of your evidence from each artifact. Write down anything you notice that might help you explain what could be occurring at the ridge. Consider whether your evidence supports or refutes your claim.

Artifact number	Evidence from the artifact of what might be occurring at the ridge	Does this support or refute your claim?
1		☐ Support ☐ Refute
2		☐ Support ☐ Refute
3		☐ Support ☐ Refute
4		☐ Support ☐ Refute
5		☐ Support ☐ Refute
6		☐ Support ☐ Refute
7		☐ Support ☐ Refute
8		☐ Support ☐ Refute
9		☐ Support ☐ Refute

Look back at your initial claim. Does this evidence support or refute your initial claim? What particular pieces of evidence best support or refute your claim, and why?

Name: ______________________ Date: ______________________

Making Predictions



We have learned a lot about how plates move, and what happens when they collide and spread apart. Use the image below to answer questions about what is happening to the land and mountains on and between these three plates.

1. The Andes Mountains (labeled by a big box) are located on the west side of South America where the Nazca plate is interacting with the South American plate. We know the oceanic Nazca plate is going under the continental South American plate, and then melting back into the mantle. We also know that the plates on either side of the Mid-Atlantic Ridge are spreading apart making new plate material. Using that knowledge, what do you predict will happen over time to the:
    - Pacific Ocean
    - Nazca Plate
    - Andes Mountains
    - Mid-Atlantic Ridge

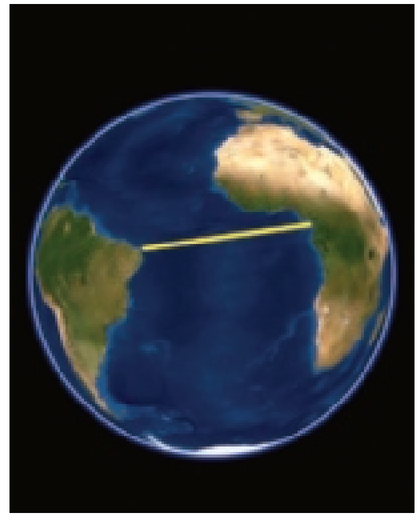
Pacific Ocean	
Nazca Plate	
Andes Mountains	
Mid-Atlantic Ridge	

2. If the Andes Mountains are growing because of interactions between the Nazca plate and the South American plate, do you think the Andes Mountains have always been here? Explain your answer.

3. If the Mid-Atlantic Ridge is spreading apart about 1.9-2.2 inches (roughly 4-6 cm) per year, does that mean that oceanic plate material has always existed in the Atlantic Ocean? Would there be any changes to the two continents on either side of the Mid-Atlantic Ridge? Explain your answers.

Name: ______________________________ Date: ______________________

Calculating Plate Movement



Scientific Data

Remember from Lesson 8 that the plates are moving at an angle away from the Mid-Atlantic Ridge, so we can't just measure the distance from one continent to another. Instead, we need to measure how far they are from the ridge at the angle they are moving. If we track back the continents to where they could have possibly touched at the ridge, the continents would have moved roughly 7000 kilometers (4,300 miles) apart from each other. Scientists also estimate that the two continents move 48 to 56 millimeters apart from each other every year.

Part 1: Estimating plate movement

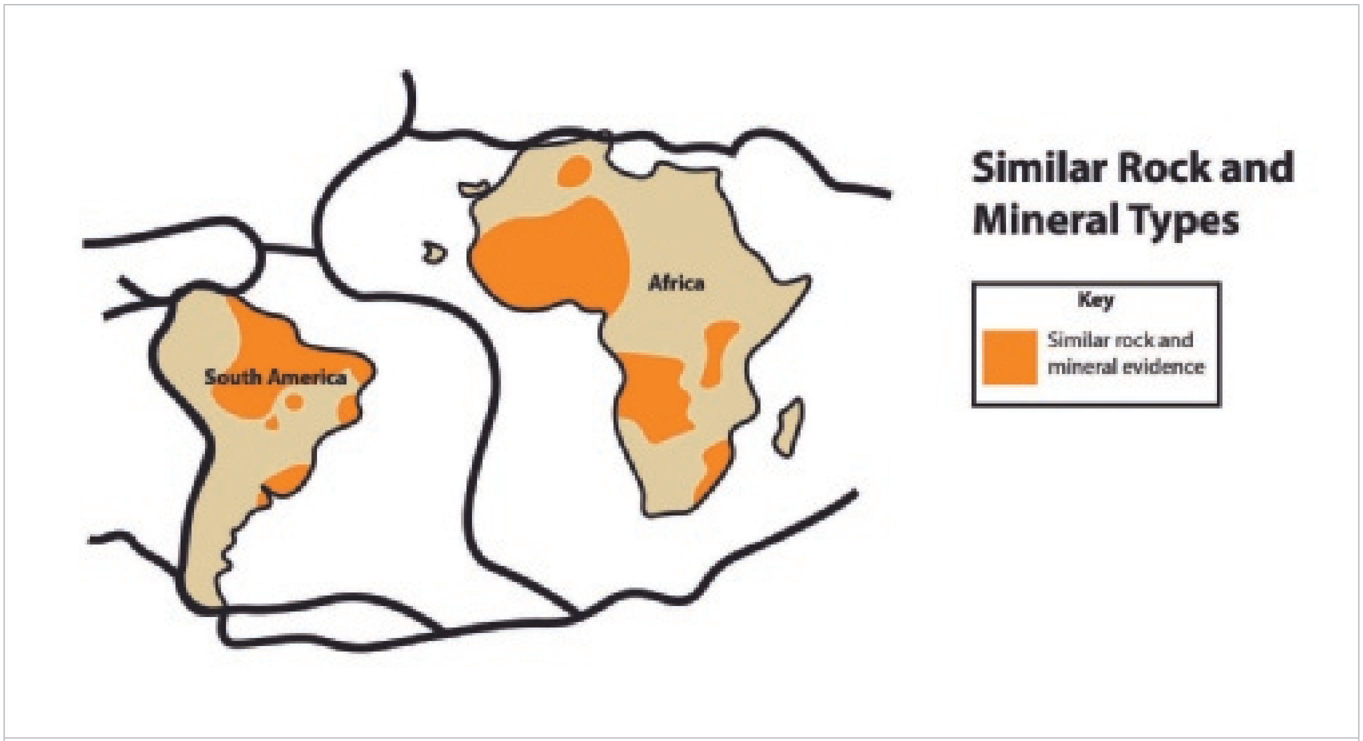
Now knowing how fast and how far the plates are moving each year, let's make some class estimates about how long ago they might have been touching. We can then check the distance to see if we get close to the actual distance between the two continents.

Class time estimates	Rate	Math we did as a class to figure this out
	48mm	
	56mm	
	48mm	
	56mm	

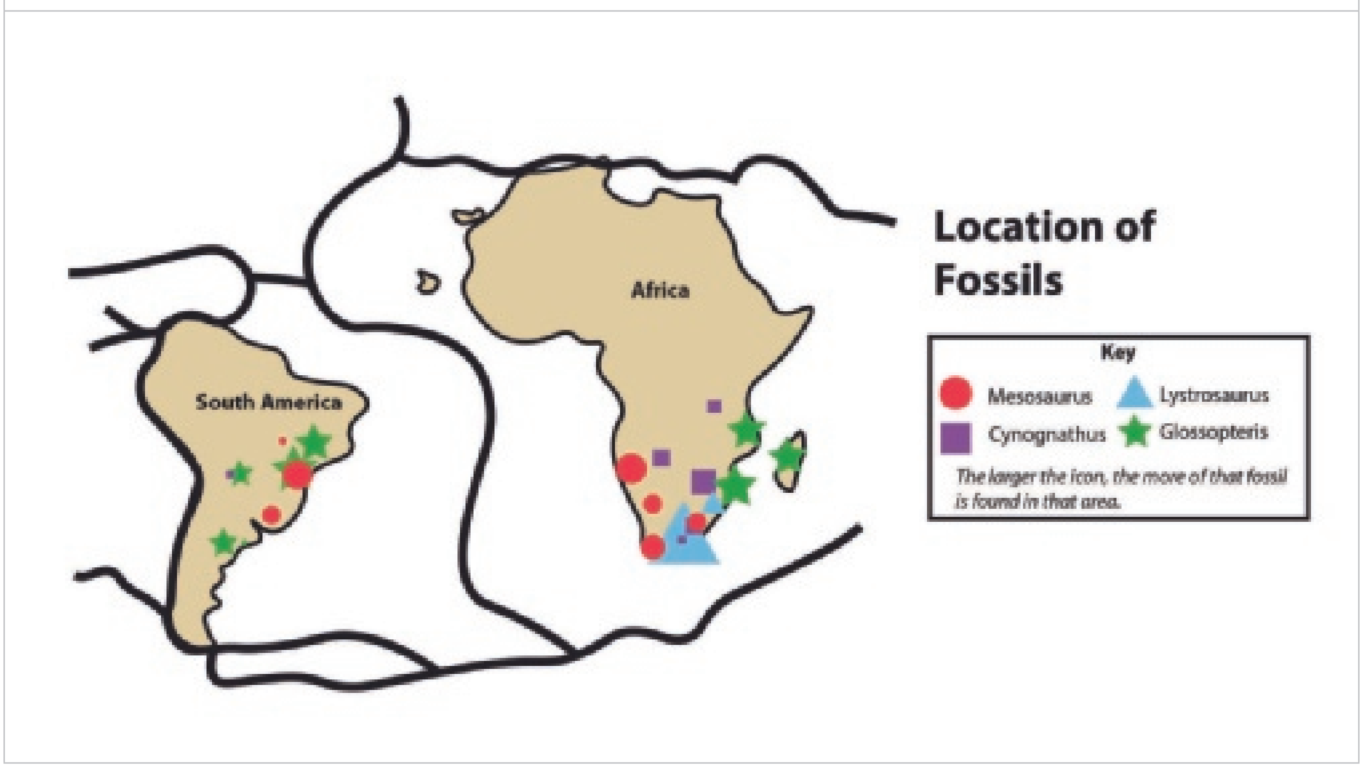
Part 2: Using estimations and averages constructed by scientists

Scientists have used multiple sets of data and sources of evidence to approximate, or come close to, how quickly the two plates are moving away from the Mid-Atlantic Ridge over time. Let's now start with the distance from continent to continent and the rates approximated, or estimated, by scientists to figure out how long ago these two plates might have been together. Round your answer to the nearest million years.

Distance plate may have traveled since being joined at the Ridge in km	Convert km to mm by multiplying by 1,000,000	Total rate of movement in mm (record it in this column)	Divide this by the estimated rate of movement per year	Amount of time it would have taken to move from the Ridge (record it in this column)
A 7000 km	X 1,000,000	mm	÷ 48 mm/yr	yrs
B 7000 km	X 1,000,000	mm	÷ 56 mm/yr	yrs

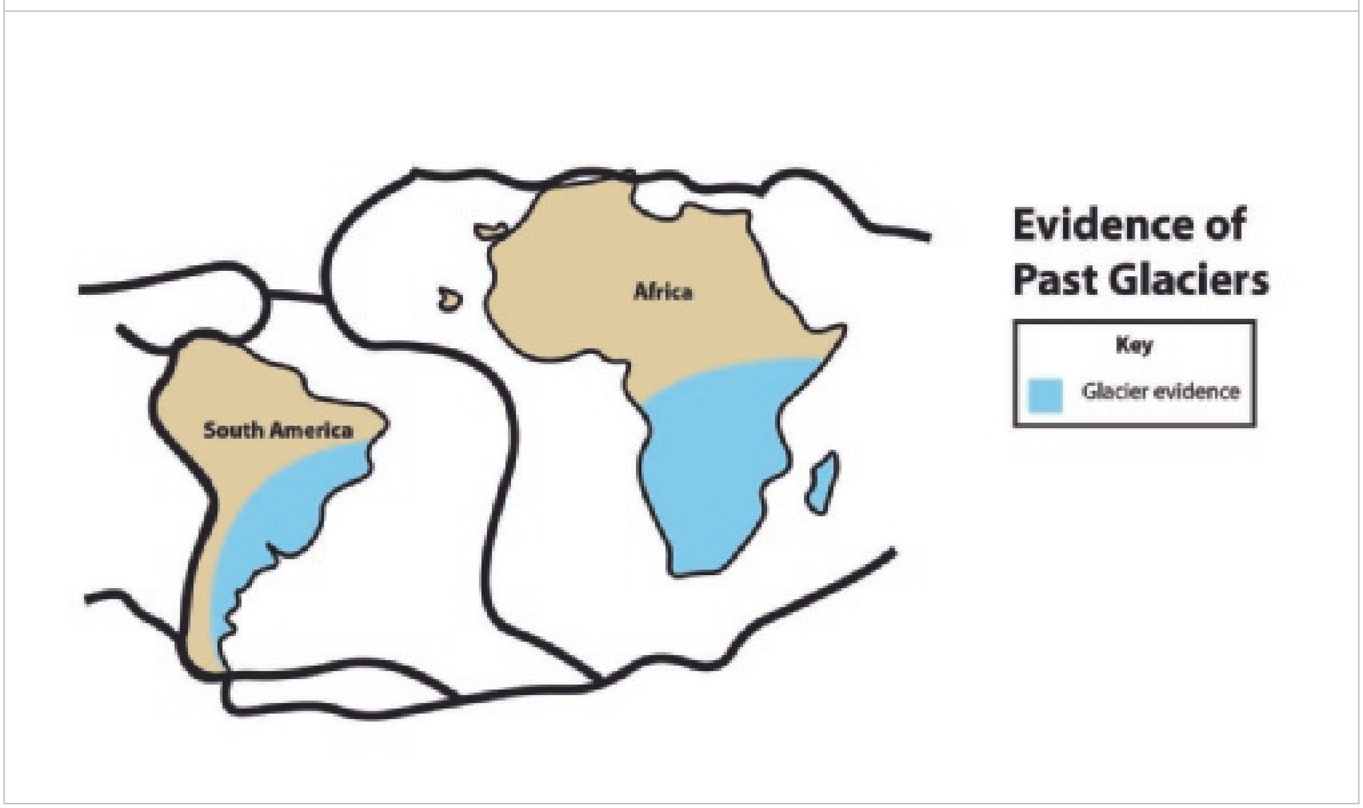


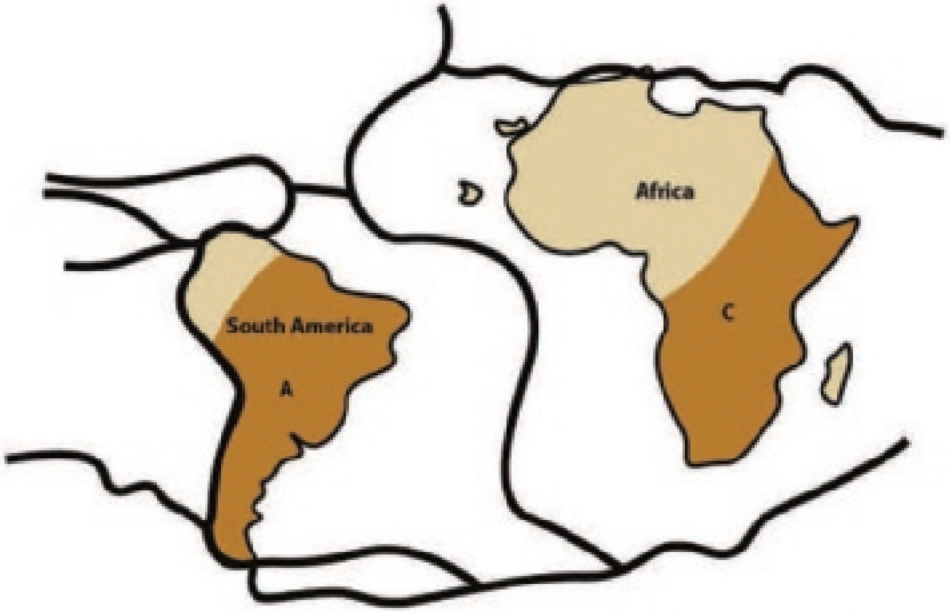
Similar Rock and Mineral Types
Africa
South America
Key
Similar rock and mineral evidence



Location of Fossils
Africa
South America
Key
Mesosaurus
Lystrosaurus
Cynognathus
Glossopteris
The larger the icon, the more of that fossil is found in that area.

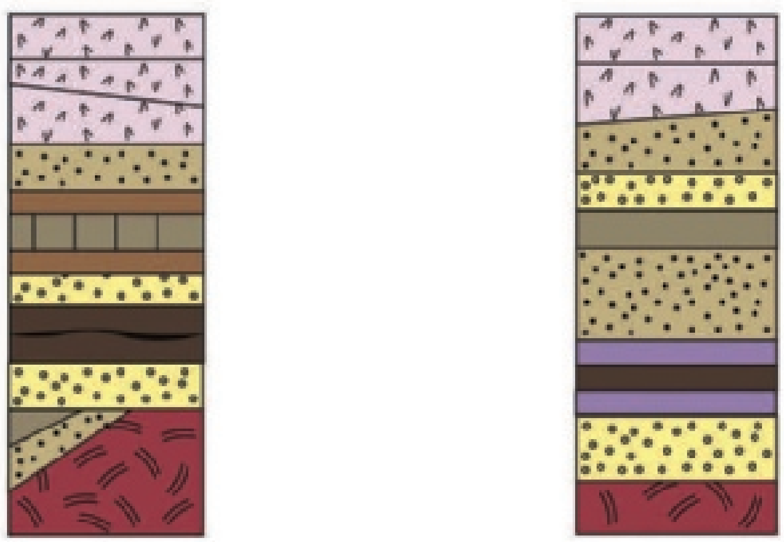

Evidence of
Past Mountains
Key
Mountain evidence
Africa
South America


Evidence of
Past Glaciers
Key
Glacier evidence
Africa
South America



Similar Rock Layers and Formations

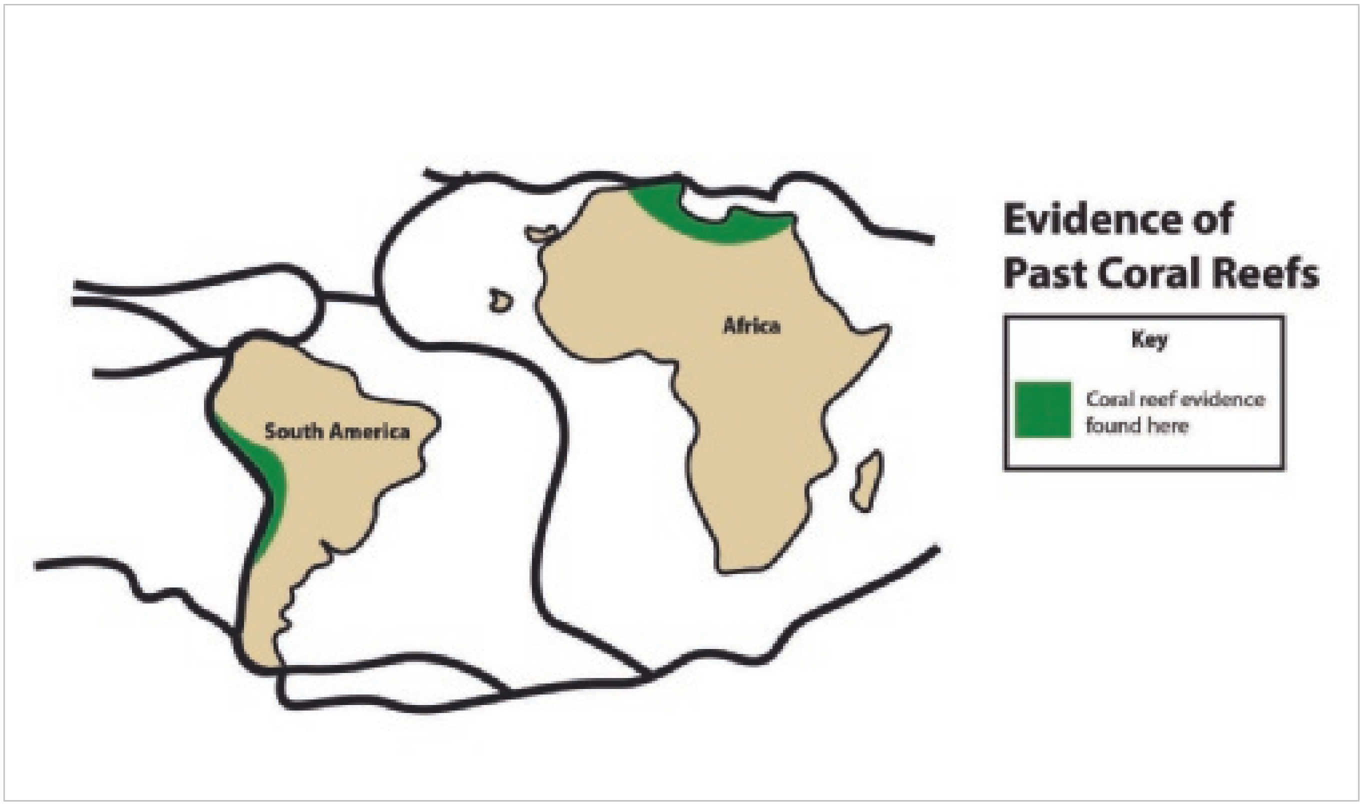
Similar Rock Layers and Formations KEY



Sample A

Sample C

Each rock layer here is similar to the rock layers found for each section of the map.


Evidence of Past Coral Reefs
Key
Coral reef evidence found here
Africa
South America

Talking Sticks Protocol for Our Continental Datasets

1. The first group member will pick up a pencil. The person with the pencil will take **1 minute** to share their data with the group. All other group members will listen quietly. All questions will be saved for after the group member is done talking.
2. As the group member is sharing, others should be looking at their continent data and marking anything that they notice that is **similar or different** between the data being presented and their data.
3. Group members without the pencil should **record any patterns** they notice on an area of their data map by marking it with a dry erase marker on the page protector above their maps.
4. After the person with the pencil has finished sharing their data, the group can use up to a minute to **ask any clarifying questions**.
5. The pencil will then be passed **one person to the left.**
6. This process continues until all people in the group have shared their data.

After everyone has shared their datasets, discuss any connections between the datasets you have noticed as a group.

Lesson 10 Exit Ticket

Make a claim about Africa and South America by completing the sentence below:

Africa and South America ________________ touching in the distant past.
were / were not

What evidence did you see today that supports your claim? Record the source(s) of evidence that helped support your claim in the first column. Use the second column to explain why that source of evidence supports your claim.

Source(s) of evidence	Why this source of evidence supports your claim

Does looking at more data from the same time period make you more sure or less sure about your claim above? Explain.

____

____

____

Do you also think that other continents might have been in different places during that time period? What data would you want to look at to determine if they were in different places?

____

____

Name: ____________________ Date: ____________________

Erosion Rates

There are many things that can wear down or break up land over time. Some of these are running water, glaciers, waves, wind, and gravity. Each of these can interact with the materials on and sometimes just below the surface to wear down the land. Look at the image to the right. As water is moving over or just under the surface of the land, it can pick up loose materials and carry them to another part of the stream or river. You may have seen this happen in a drainage ditch, river, or stream in the past. Consider your prior experiences with water moving. How does water moving around you change the landscape over time?

How will the water in this river and waterfall affect the land around it over time?

What if the river were to move faster? What if the river were to have more water in it and be deeper?

When scientists want to figure out how these different erosion processes affect the surface of Earth, they collect data about each of them for a specific location. Then they compile the data they have for each process to determine the overall effects on the land from all the erosion processes happening at that location. After compiling all this data together, they get a number that represents the rate that erosion is wearing down the land in a specific location or area over time. This is called the **erosion rate**. After examining multiple locations and conducting tests and simulations, scientists have determined that two of the biggest contributors to erosion are wind and water. Let's read on to consider the roles of these two larger erosional processes on erosion rate, and learn more about how erosion rate is determined by scientists.

Let's think about this for a minute by using this image of the mountain above. In the picture you can see that there are glaciers on these mountains. Glaciers are large, slow moving rivers made of ice that travel very slowly and flow over the land over long periods of time. One of the glaciers in this picture looks like a curvy line down the mountain that almost reaches the lake. If air temperature increases, what do you think will happen to the glacier with a higher air temperature over time? It will slowly begin to melt! And as the glacier melts the liquid, water flows down the mountain until it reaches the lake. As the water flows down the mountain, it picks up loose material, like rocks, and sediments, and so forth, and carries these with it until it reaches the lake where these sediments get deposited. If this continues to happen for a long period of time, what do you expect to see happening to the area where the water is moving across the landscape? What do you expect to see happening where the water reaches the lake?

Glaciers also shift and move as they are pulled down the mountain by gravity, dragging with it any rocks or soil in its path. If the glacier continues to melt and move over an extended period of time, what would you expect to see happen to the mountain where the glacier is?

For this case of ice, or solid water, moving across a mountain, if scientists want to determine the rate this mountain is being eroded over time, they would collect the data about the glacier melting and moving over time including: how much the glacier melts, how fast the glacier is moving and how heavy the glacier is, how much deeper the lake gets, and how much sediment or rocks get deposited in the lake. They would then put all these numbers together to figure out how much the mountain is being worn down, or eroded, over time and report this as a rate in millimeters per year. In other words, the rate, or number they report, is how many millimeters in a year the mountain, or land is decreasing over time. The erosion rate for Mt. Everest is 9.3 mm/year. This means that the mountain is eroded or worn down 9.3 mm/year. That's just just under 1 cm. If the erosion rate of Mt. Everest is 9.3 mm/year, how is it possible that Mt. Everest is still increasing in elevation?

The erosion rate for Mt. Mitchell in the Appalachian Mountains is 5mm/1000 years. What do you notice about these two rates? How do they compare?

Name: ______________________________ Date: ______________________

Erosion Rates vs. Uplift Rates

Part 1: Mt. Everest and the Himalayas

The erosion rate for Mt. Everest is 9.3 mm/year. The uplift rate is 2 cm/year. Let's represent what this looks like in the space below so we can make sense of what this means for how the mountain is changing over time.

What is the relationship between uplift rate, erosion rate, and elevation change of a mountain? Use the sentence below to capture what is happening at Mt. Everest.

When the uplift rate at Mt. Everest is _______________ (**greater than** or **less than**) the erosion rate, the height of the land at Mt. Everest will _____________ (**increase** or **decrease**).

If you were to see Mt. Everest in 1,000 years from now, do you predict there would be any noticeable changes? Do you think it would be taller? Shorter? Why?

Part 2: Mt. Mitchell and the Appalachians

The erosion rate for Mt. Mitchell is 5 mm/1,000 years. The uplift rate is 1 mm/1,000 years. Let's represent what this looks like in the space below so we can make sense of what this means for how the mountain looks.

What is the relationship between uplift rate, erosion rate, and elevation change of a mountain? Use the sentence below to capture what is happening at Mt. Mitchell.

When the uplift rate at Mt. Mitchell is _______________ (**greater than** or **less than**) the erosion rate, the height of the land at Mt. Mitchell will _____________ (**increase** or **decrease**).

If you were to see Mt. Mitchell in 1,000 years from now, do you predict there would be any noticeable changes? Do you think it would be taller? Shorter? Why?

Name: ______________________ Date: ______________

Comparing Related Phenomena

Pick a related phenomenon with your partner. Work through the questions below to explain your related phenomena and its relationship to mountains being created and destroyed.

What related phenomena are you going to explain? List the related phenomena below and whether it is constructive or destructive:

How has your understanding of how this related phenomenon occurs changed or improved over time? Use the sentence stem "We used to think... Now we think..."

Draw a model to help explain this related phenomenon.

Think about the processes that lead to mountain construction and destruction. How is this phenomenon related, or not related, to mountains growing or decreasing in elevation?

Name: ______________________________ Date: ______________________

Science Literacy Exercise Page 1 — Use with Reading Collection 1

Roadmap for Reading

This week's reading collection focuses on understanding Earth's large-scale structures and events from where you are—on the surface! But it also takes a look at how scientists know what is going on below the surface.

"Collection 1: The Gorgeous Globe" consists of five selections.

1. Vivid Vacation Pics
2. Earth's Famous Events
3. How Deep Can You Go?
4. Seeing the Unseen
5. It's Not Their Fault

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how maps and other graphic models support the narrative text and how narrative text clarifies the maps and graphics.
- Consider how each reading relates to knowledge you gained from your class investigations in Lessons 1 and 2.

Written Response

Your writing exercise is to draw a four-panel science comic that will accurately explore one science idea from any of the first four selections in this collection.

- Copy the template that follows on a separate sheet of paper, and draw your comic in it; attach this page to the front of it when you turn it in.
- Using the comic in the fifth selection as a model, invent two characters to feature in your comic. For example, they could be two friends, two strangers, siblings, or an expert and you. The characters should differ in their personalities, attitudes, or understanding.
- In each panel, have your characters communicate about an unexpected, challenging, or important idea from one of the four readings.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	It is unclear how the dialog is related to Earth's crust and other layers and has two or more science errors.	The dialog about a science idea related to Earth's crust and other layers is clearly related to one of the first four readings but has one scientific error.	The dialog about a science idea related to Earth's crust and other layers is accurate and clearly related to one of the first four readings.	
Characters	One or both characters are missing or lack a point of view or personality to engage readers.	There are two characters, but either it is hard to distinguish them, or their point of view or personality is inconsistent across all four panels. Their contribution to reader engagement is minimal.	There are two characters, each with a different view or personality that is consistent across all four panels and contributes to reader engagement.	
Creativity	The comic is lacking in creative details that could have contributed to reader enjoyment.	There is at least one creative detail that contributes to reader enjoyment.	Many creative details contribute to reader enjoyment.	
Organization and illustrations	Fewer than four panels are used. Drawings and text are difficult to interpret.	Three of the four panels advance the storyline. The drawings and text are mostly easy to interpret.	Each panel advances the storyline. The drawings are easy to interpret, and the text is easy to read.	

Additional Feedback Notes:

Name: ______________________ Date: ______________

Roadmap for Reading

This week's reading collection focuses on how people's understanding of Earth's structure developed over time. The selections include a piece of science fiction from the mid-1800s and profiles of two scientists.

"Collection 2: A Historical Perspective" consists of four selections.

1 Wegener: A Science Outcast
2 Journey to the Center of the Earth
3 Wartime Discoveries
4 Tools of the Trade

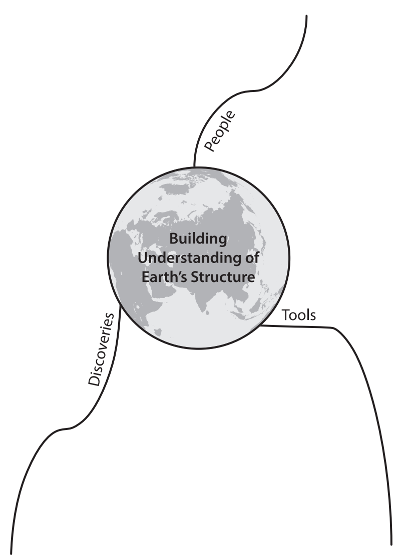
As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, an attempt to persuade, or to entertain?
- Consider how the piece of science fiction differs from the other readings in its presentation.
- Consider how each part of the reading relates to knowledge you gained from the previous part.

Written Response

Your writing exercise is to complete a concept map describing some of the people, discoveries, and tools that were used to build understanding of the structure of Earth.

- Using the partially completed organizer shown below as a template, sketch your graphic organizer to fill one side of a separate sheet of paper; attach this page to the front of it when you turn it in.
- Review the reading selections to find examples of each of the three categories of contributions to the theory. Each of the three "arms" should branch so that you have a "finger" for each example.
- Add color to improve your design. Check the connecting lines and text to make sure they are attractive and readable.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.



Evaluation Guidelines

Element	1	2	3	Feedback
Content	Map includes minimal concepts from only one or two selections.	Map includes most of the important concepts and represents at least three selections.	Map includes the important concepts from all four selections.	
Relationships of details	Organization of the details on the map is unclear or not accurate.	Linking lines and labels for detail are mostly clear and correct.	There is a linking line and label for each detail that shows relationships to the three categories correctly.	
Design	Major improvements are needed in the design of missing headings, shapes, arrows, and arrangement to fill the page.	All but one of the following are well executed: Headings, details, and shapes are attractive and easy to read. Color is used effectively to show organization of concepts. The map fills the whole page effectively.	Headings, details, and shapes are attractive and easy to read. Color is used effectively to show organization of concepts. The map fills the whole page effectively.	
Grammar and mechanics	There are five or more errors in capitalization and spelling.	There are one or two errors in capitalization and spelling.	There are no errors in capitalization and spelling.	

Additional Feedback Notes:

Name: ______________________________ Date: ______________________

Science Literacy Exercise Page 3 | Use with Reading Collection 3

Roadmap for Reading

This week's reading collection takes a closer look at the rock that makes up Earth's tectonic plates. The selections include one that is written like a science fair project that some 10th-grade students might work on.

"Collection 3: The Rocking Rock Cycle" consists of five selections.

1 What's That Rock?

2 Fossils

3 Building on Bedrock

4 Volcano Lessons

5 The Laws of Layers

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Notice how the authors use subheadings to organize their text and make it understandable.
- Consider how the text supports the graphics and how the graphics support the text.

Written Response

Your writing exercise is to complete a graphic organizer's if/then statements to accurately summarize a cause-and-effect relationship from each reading.

- Fill in the blank bubbles on the graphic organizer on page 84; make sure this page has your name on it.
- Notice that you will write both "if" and "then" statements. Follow the style provided, and use complete sentences.
- Each of the five readings should have an "if/then" statement.

Evaluation Guidelines

If	Then
If, over millions of years, dead organisms sink to the bottom of a body of water, the water dissolves some of the parts of the shells and pressure breaks down other parts, and there is pressure on the sediments,	
If you can compare a fossil you find to ones that are identified in field guides,	
	then the building foundation may shift and crack.
	then a chain of volcanic islands will form in the middle of a plate.
If rock layers appear level or flat,	

Name: ______________________ Date: ______________

Science Literacy Exercise Page 4 Use with Reading Collection 4

Roadmap for Reading

This week's reading collection focuses on questions about Earth and its features. Several of the selections include maps or other displays that can be used to identify time or space relationships.

"Collection 4: The Mysteries of Earth" consists of five selections.

1 How Did They Get There?
2 Unsolved Mystery: The Marianas Trench
3 Visit the Natural Wonders!
4 Is Yellowstone About to Explode?
5 Induced Earthquakes

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Consider how each part of the reading might support the claim you choose for your written response.

Written Response

Your writing exercise is to complete a thoughtful paragraph about whether human activities can cause mountains to sink.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Introduce a claim in your topic sentence, either
  - *Human activities **cannot** cause mountains to sink, or*
  - *Human activities **can** cause mountains to sink.*
- Build on the topic sentence to complete a well-constructed paragraph to support your claim.
- Use details from this unit as evidence to support your reasoning.
- Keep your style formal throughout your paragraph, as you would for an audience of scientists.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	There is an inadequate argument in support of a claim made in the topic sentence.	There is adequate completion of a structured paragraph about mountains sinking due to human activities but weak in reasoning or evidence to support reasoning about the topic sentence.	There is thorough support of the chosen topic sentence, citing specific, relevant details from reading selections and classroom investigations.	
Supporting sentences (details)	There are incomplete sentences or details irrelevant to the claim made in the topic sentence.	There are complete sentences but too few, lacking in support from the readings or investigations, or unclear relationship with the topic sentence.	There are at least five complete sentences, encompassing three major points that support the topic sentence.	
Organization and transitions	There are statements with little clear relationship to the topic sentence or each other.	Key supporting details are present, but transitions are absent or choppy.	Ideas are in an order that helps the topic make increasingly more sense.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

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