BEAM Will Rock You

Zachary Huang | Spring 2021

Field(s) of Interest : Geology

Brief Overview

In this lesson, we will be focusing on the science of rocks, specifically on the processes and movements happening underneath our feet. By exploring, visualizing, and experimenting with different models of the Earth, mentees will learn not only how the Earth changes over time, but also the causes of natural phenomena like earthquakes, mountains, and valleys.

Agenda

- Introduction (5 min)
- Module 1 : Continental Citrus (15 min)
- Module 2 : Earth's Biggest Breakup (10 min)
- Module 3 : It's Not My Fault (15 min)
- Module 4 : Mantle Convection Love Connection (10 min)
- Conclusion (5 min)

Teaching Goals / Key Terms:	**Mentor Development Goals:**
• **Tectonic Plates -** Massive, irregularly shaped slabs of rock that form the **lithosphere** • **Theory of Plate Tectonics** - Theory that massive, irregularly shaped slabs of rock form Earth's surface and shift over time to create phenomena • **Plate Boundaries -** The boundaries of tectonic plates, where plates move in relation to each other, causing various natural phenomena • **Convection Currents** - The transfer of heat allowing warmer substances to rise	• **Teaching With Simulations** - Online simulations can be super helpful for understanding new concepts • **Addressing Different Learning Styles** - Try to teach in a way that's inclusive of the different learning styles your mentees may have • **Setting Personal Goals** - Pick your own goal or strategy to work on this lesson!

Mentor Development Notes

Written by Nicole Zhu

Teaching with Simulations

Many of these modules include simulation-based activities, which are a great opportunity for students to play around with the material and solidify their understanding of new concepts. A good approach to teaching with simulations is to demo the simulation through a shared screen while engaging in an interactive dialogue with your mentees. Ask them questions about what they think will happen in the simulation. Make sure to save some time for your mentees to play around with the simulation on their own too!

Addressing Different Learning Styles

As covered in our previous MD presentation, “Strength Building,” we can categorize the different learning preferences into four groups: kinesthetic learners, auditory learners, reading/writing learners and visual learners. While it’s easier to cater to specific learning styles in small groups, it becomes more difficult when working with larger groups.

When working with a larger group of mentees, try to diversify your teaching approaches to be more inclusive of the different learning preferences your mentees may have. For example, a simulation can be a great way to conceptualize a new topic for kinesthetic and visual learners. Pairing that with a short post-simulation discussion can be a great way to help auditory learners work through the concepts as well!

Setting Personal Goals

Now that we’re two-thirds of the way into the semester, this is a great time to reflect on the progress you’ve been making towards your own personal goals. What are some of your strengths and weaknesses when mentoring in the classroom? Are there any skills that you want to work on developing? Think back to the goals that you discussed in this past week’s reflection project, and for this week, pick one change you want to make to help you achieve your goals. Do your best! You got this :)

Background for Mentors: Module 1

Module 1

- Lithosphere
- Asthenosphere
- Tectonic Plates

The surface of the Earth that we walk on is called the **lithosphere**, representing the rigid, outer layer of the Earth. While it partially consists of the **crust**, it's important to note that it includes the upper **mantle** as well. While this might be confusing, it might be better to think of the **lithosphere** as a layer defined *specifically for the tectonic plate theory*. The **Asthenosphere** represents the layer right under that, made of the **mantle** underneath that of the lithosphere. Due to this, it is far more fluid and consists primarily of **magma**.

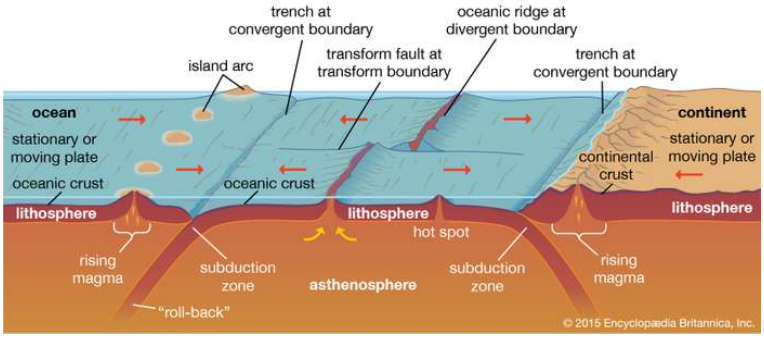

Figure 1 : Lithosphere and Asthenosphere at a Boundary

The lithosphere, as we know it, is mostly divided into huge slabs of Earth called **tectonic plates**. These plates form the Earth's surface as we know it, and are what we are standing on right now. The **theory of tectonic plates** states that the Earth's solid crust is separated into these plates, that respectively float over the more fluid asthenosphere, letting them gradually shift over time.

Figure 2 : Earth's Surface separated into Tectonic Plates

Background for Mentors: Module 2

Module 2

- Theory of Plate Tectonics
- Supercontinent
  - Pangea

Building upon the **Theory of Plate Tectonics** mentioned before, **continental drift** refers to the quite literal idea that continents were "drifting" across the Earth, plowing into oceans and each other. After examining a combination of fossil records, glacier remains, and rock layers, Alfred Wegener realized that the evidence was strangely separated by continent. Piecing it back together like a puzzle, he hypothesized that these separate continents had in fact drifted far away from their original positions, originally forming a singular continent.

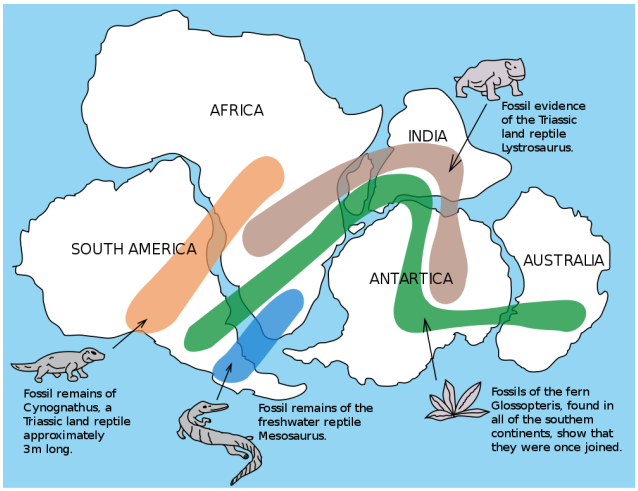

Figure 3 : Rocks, Fossils, and Glacier Evidence

Examining it further, he discovered that some continents "fit" together extremely cleanly, i.e., South America's east coast and Africa's west coast. Due to this, we were able to form hypothetical **supercontinents**, a large continent formed out of multiple smaller ones. **Pangea**, the most recent supercontinent, was hypothesized to exist around 240 million years ago.

Figure 3 : Earth's Shifting Surface

Background for Mentors: Module 3

Module 3

- Plate Boundaries
- Earthquakes
- Subduction
- Continental / Oceanic Crust

With plates shifting on top of the asthenosphere, there will be different **plate boundaries** between each tectonic plate. Depending on the motions of the plates, these boundaries can be categorized. As such, there are three main types of boundaries: **divergent**, where plates move away, **convergent**, where they come together, and **transform**, where they slide against each other.

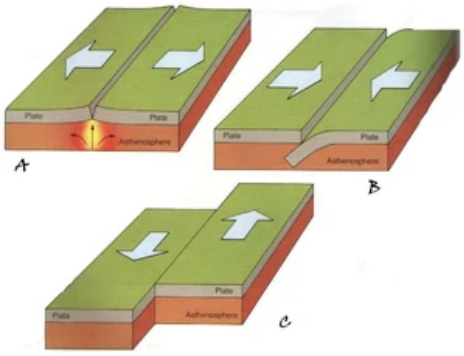

Figure 5 : Different Types of Boundaries

These different types of plate boundaries respectively cause different phenomena and features to occur. The features can often be figured out from the movements. Often, chains of mountains or trenches accompany convergent boundaries, as one plate is forced above the other. In divergent boundaries, magma often rises through the gap created, creating new trenches. Transform plate boundaries grind against each other, with earthquakes happening often.

Earthquakes are a common feature that occurs with all plate boundaries. As plates collide, the stress and strain eventually overcome the friction holding the plates against each other. Due to this, they commonly occur at transform and convergent boundaries, and divergent boundaries to a lesser degree.

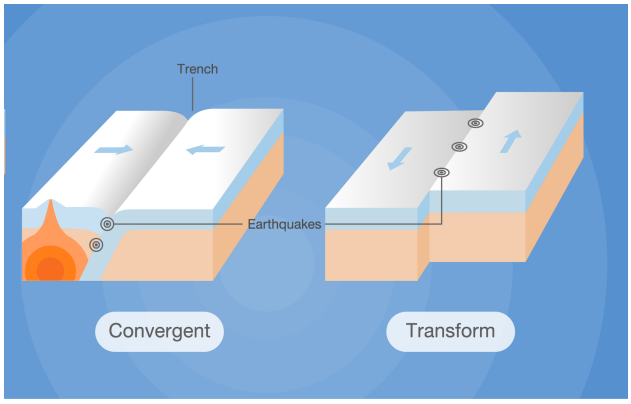

Figure 6 : Common Causes of Earthquakes

Background for Mentors: Module 4

Module 4

- Magma
- Mantle Convection
- Convection Currents
- Hot Spots / Cold Spots

The **Asthenosphere**, as mentioned, is far more fluid, as it consists primarily of **magma**, a hot fluid / semifluid material. Many people also know it by the name of *lava*, which represents the part of it that breaks through to the Earth's surface. Due to its fluid nature, **convection currents** naturally occur due to the differences in temperature within the mantle. These movements are brought on by *convection*, which is the movement within a fluid caused by the tendency of hotter materials to rise up, due to their smaller density. This is due to the relatively fast movement of the molecules, causing there to be greater distance between, and therefore less density. Due to this, the cooler magma higher up in the layer sinks, and the hotter magma beneath rises with these movements.

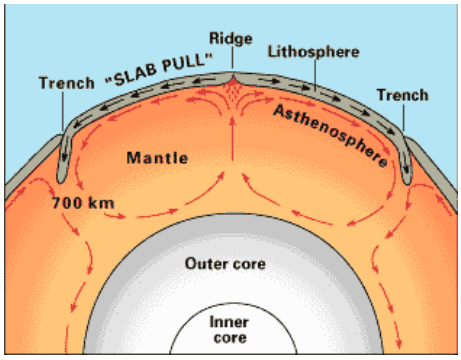

Figure 7 : Mantle Convection

These currents provide one possible way for the plates to move, as the flow of these currents slowly direct the plates above them.

Hot Spots and *Cold Spots* respectively represent regions of the mantle where the magma is anomalously hot or cold, respectively, compared to the surrounding mantle. There are several hypotheses for this, such as mantle plumes, for example. Noticeably, hot spots can cause phenomena such as volcanoes, independently of plates.

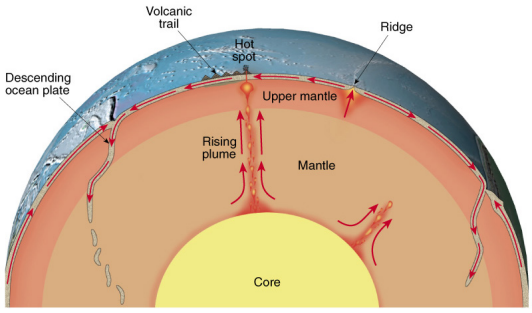

Figure 8 : Hot Spots

Introduction

Understanding geology and tectonic plate theory is important, as it allows us to understand why the Earth is the way it is today, and how it might be in the future.

Concepts to Introduce ● What's the surface of the Earth really made of? ● Why do earthquakes occur? ● What lies underneath us? ● Earth is made up of several layers, with a solid surface (**crust)** and a more fluid interior (**mantle and core)**. ● We will be focused on not only the surface of the Earth, but the natural phenomena resulting from it.	**Current or Past Events** ● The impact of plate tectonics in geology over time is undeniable. Over the course of millions of years, Earth's surface has transformed drastically, changing from one continent to seven. ● Even today, continents still shift on average about 0.6 inches every year ● However, these concepts still impact us today, with geographic features and phenomena such as mountains, valleys, earthquakes, and other phenomena.
Questions to Pique Interest ● Why does the surface of the Earth change so much over time? ● Why is the ground we're standing on shifting? ● What causes earthquakes? ● What causes volcanoes, mountains, valleys, and other physical features to occur?	**Inspiring Scientists, Careers, Applications** ● Geology - Earth science field dealing with the solid Earth and primarily rocks. ● Environmental Engineering - Field that deals with creating solutions to improve and protect the health of living organisms.

Module 1 : Continental Citrus (15 min)

This module will introduce mentees to the different layers of the Earth through a build using simple materials, and will demonstrate the basic structure of plate tectonics.

Teaching Goals	**Materials**
1. **Lithosphere -** The solid surface layer of the Earth 2. **Asthenosphere -** The viscous, magma-filled layer underneath the Lithosphere 3. **Tectonic Plates** - Massive, irregularly slabs of rock that form Earth's surface	• Orange • 7 Toothpicks

Procedure

1. Begin by observing the orange. The outer peel of the fruit represents the **lithosphere**, the primarily solid outer layer of the Earth.
2. Begin by peeling the orange into 5-7 pieces. The pieces will represent the **tectonic plates** of this "Earth".
3. Observe the more fluid interior of the orange. This represents the **asthenosphere**, or magma-filled layer of the Earth.
4. Stick toothpicks through the peeled pieces of the orange.
5. Reattach the pieces to the orange. As we're using the pieces we peeled off, there shouldn't be any overlap or significant missing space. This represents the **tectonic plates** forming the **lithosphere.**

Figure 9 : Take off the Orange Peel in 5-8 Large Chunks

Figure 10 : Reattach the Peel with Toothpicks

Notes

If an orange is not available for mentees, other spherical citrus fruits can act as a replacement. Additionally, if their orange is not solid enough, another spherical object can act as the core of the Earth.

Module 2: Earth's Biggest Breakup (10 min)

This module will further focus on the Theory of Tectonic Plates, and will display how the Earth has actually changed over time due to it, through an interactive puzzle. Mentees will have the opportunity to reconstruct Pangea themselves, and see Wegener's reasoning.

Teaching Goals	**Materials**
1. **Theory of Plate Tectonics** - Hypothesis stating that massive, irregularly shaped slabs of rock form the Earth's surface 2. **Supercontinent** - A super landmass formed out of most or all of Earth's continents a. **Pangea** - The most recent supercontinent to have existed, formed out of all Earth's landmasses	• Pangea Puzzle

Procedure

1. Begin sharing screen, and open up the puzzle simulation.

2. Show mentees how to move and rotate continents. Make sure to emphasize that the boundaries between continents will not be perfect.

3. Afterwards, show mentees the different types of **evidence (rocks, fossils, glaciers)**. Briefly overview each, but feel free to avoid specifics, keeping in mind the 5 minute timer. In some sites, it might be better to focus on fossils, as they have the clearest visual indicators.

4. Give mentees the link to the puzzle and ensure they all start at the same time. Give them up to five minutes to work on their puzzle. Remember the timing for this, as there is a time limit allocated for the simulation.

5. At the end of it, show mentees a picture of

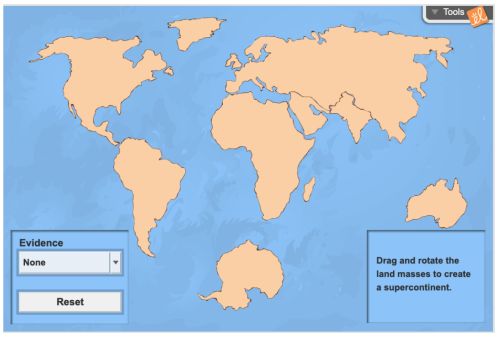

Figure 11 : Initial Simulation Screen

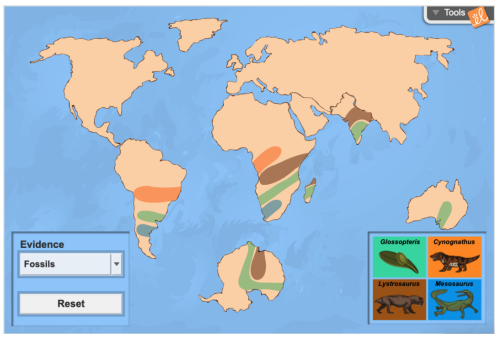

Figure 12 : Simulation with Fossil Evidence

what Pangea looked like on the slide, along with the transitory periods.

Figure 13 : Example SImulation Supercontinent

Note:

For this module, time is extremely sensitive, due to the mentees being locked out after five minutes. Make sure to inform them of the time limit, or limit them to five minutes or less with the simulation. Also, make sure to emphasize that it isn't important to get it perfectly correct. Even Wegener himself didn't get it perfect!

Module 3: It's Not My Fault (15 minutes)

This module will demonstrate various plate boundaries, as well as their accompanying physical features and phenomena through an interactive, time based simulation.

Teaching Goals	Materials
1. **Plate Boundaries** a. **Convergent -** Relationship where plates are colliding; can create mountains b. **Divergent -** Relationship where plates are moving apart; can create valleys c. **Transform** - Relationship where plates are sliding past each other; the friction can cause earthquakes 2. **Oceanic Crust** - Relatively thinner portion of the Earth's crust, located underneath the oceans 3. **Continental Crust** - Relatively thicker portion of Earth's crust, forming continents 4. **Subduction** - Sideways and downwards movement of a plate back into the mantle	• Simulation

Procedure

1. After introducing the concepts of plate motion, share the simulation link with the mentees. A mentor can also share their screen.

2. Introduce the respective types of plate movements.

3. First, run through the divergent simulation. Ask the mentees to predict what might happen, and simulate using the maximum time length. Make sure to emphasize the physical features and phenomena created with the movement.

4. Encourage the mentees to mess around with the time steps; Emphasize that plate

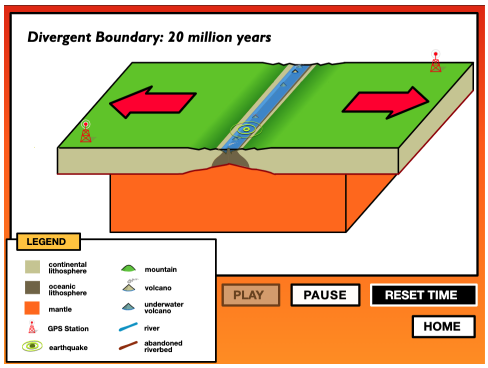

Figure 14 : Divergent Boundary

movement is a **slow** process. It takes around a year for North America to move one inch!

5. Before moving on, make sure to try out the simulation with different time lengths.

6. Repeat with the transform and convergent boundaries.

7. If advanced enough, mentors can also run through the oceanic-continental simulations, which simulate **subduction**. Make sure to emphasize that the oceanic crust is pushed back into the asthenosphere.

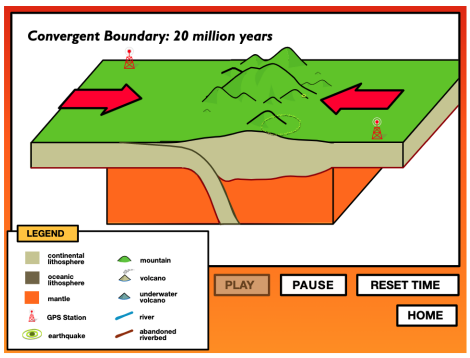

Figure 15 : Convergent Boundary

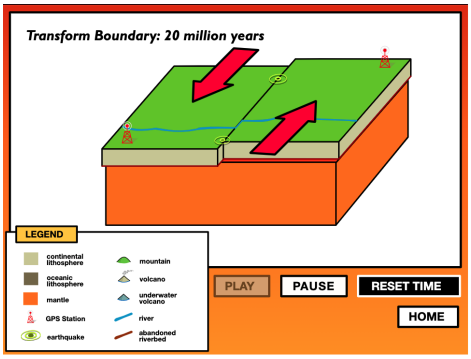

Figure 16 : Transform Boundary

Notes:

This simulation is fairly open ended, so make sure to be conscious of time. Make sure to foster class participation and ask plenty of questions. Using chat or the zoom polling feature could be a good way to increase participation.

Module 4: Mantle Convection Love Connection

This module will introduce and explain the concept of convection currents. Through a video and a simulation, mentees will have the opportunity to see and experiment with convection currents.

Teaching Goals	**Materials**
1. **Magma** - molten natural materials found beneath the surface of the Earth 2. **Convection Currents** - movements caused by a difference in density; this allows magma to rise underneath the surface **3.** **Hot Spots / Cold Spots** - An area in Earth's mantle, where the magma is hotter / colder than the surrounding magma	• Video • Interactive Earth

Procedure

1. Introduce the idea of convection through familiar concepts, such as steam or smoke.

2. Show mentees the video displaying convection in action, explaining that this is happening underneath our feet.

3. Open the simulation. It will initially be stable, but will chain react as soon as one hot or cold spot is created.

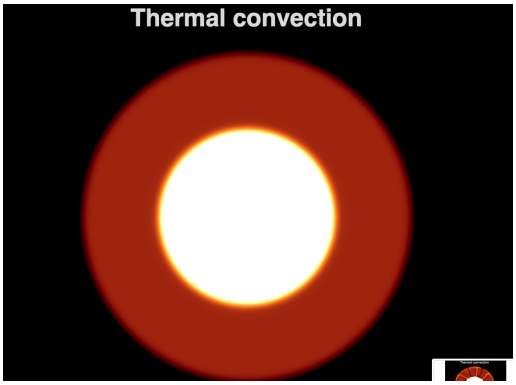

Figure 17 : Initial Simulation

4. Focus on the circular motions shown on the mantle. This is due to the **convection currents**, caused by the **hot spots** in the simulation.

5. Show mentees how to create their own **hot spots** and **cold spots**.

6. Give mentees the link for the simulation.

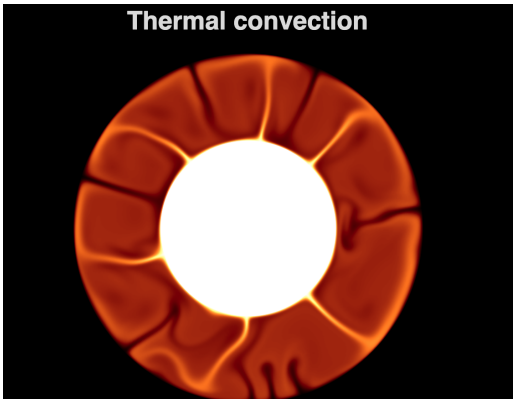

Figure 18 : Simulation With Hot / Cold Spots

7. Let the mentees experiment with the

simulation. Ask them what they notice about the simulation. Some good questions to ask are:

a. What happens to the flow of magma when you create a hotspot?
b. What happens to the flow of magma when you create a coldspot?
c. How do these motions influence plate tectonics?

Notes

Feel free to cut the video short if necessary, or just discuss examples of convection. Steaming food and the water cycle are great examples of this. Additionally, the simulation will initially be stable, but as soon as one hot spot or cold spot is created, it will create a chain reaction. Since this is a simulation based activity, make sure to use chat and the polling feature in order to increase participation.

Conclusion

In order to wrap up the lesson, ask the mentees what concepts they've learned about geology, and what other phenomena they're curious about.

References

- https://www.gns.cri.nz/Home/Learning/Science-Topics/Earthquakes/Earthquakes-at-a-Plate-Boundary/Tectonic-Plates-and-Plate-Boundaries
- https://www.ck12.org/earth-science/lithosphere-and-asthenosphere/lesson/Lithosphere-and-Asthenosphere-HS-ES/
- https://www.nationalgeographic.org/encyclopedia/lithosphere/
- https://pubs.usgs.gov/gip/dynamic/understanding.html
- https://sciencing.com/causes-convection-currents-mantle-6581412.html
- https://divediscover.whoi.edu/archives/tectonics/boundaries.html

Summary Materials Table

	Amount per Site	**Expected $$**	**Vendor (or online link)**
Orange	1		

Toothpicks	5-8		