Focus of Instructional Segment: Geologic Processes

Earthquakes give information about the Earth's structure.	
Student Science Performance	
Grade or course; HS Earth Science	**Title:**
Topic: Earthquakes and Plate Tectonics	Mapping Earthquakes

Performance Expectation for GSE:

SES1. Obtain, evaluate, and communicate information to investigate the composition and formation of Earth systems, including the Earth's place in the solar system.

b. Ask questions to evaluate evidence for the development and composition of Earth's early systems, including the geosphere (crust, mantle and core), hydrosphere and atmosphere.
(*Clarification statement*: The differentiation by density of Earth into crust, mantle and core should be included in this element.)

c. Develop a model of the physical composition of Earth's layers using multiple types of evidence (e.g. Earth's magnetic field, composition of meteorites and seismic waves).
(*Clarification statement:* Earth's layers should include crust, mantle, inner core and outer core.)

SES2. Obtain, evaluate, and communicate information to understand how plate tectonics creates certain geologic features, landforms, Earth materials, and geologic hazards.

a. Construct an explanation based on evidence that describes the mechanisms causing plate tectonic motion.
(*Clarification statement:* The role of radioactive decay as the source of energy that drives the process of convection should be studied as part of this element).

b. Develop and use models for the different types of plate tectonic settings (convergent, divergent and transform boundaries).
(*Clarification statement*: Subduction zones, continental collisions, rift zones, and ocean basins should be included.)

c. Construct an explanation that communicates the relationship of geologic features, landforms, Earth materials and geologic hazards to each plate tectonic setting.

d. Ask questions to compare and contrast the relationship between transformation processes of all rock types (sedimentary, igneous, and metamorphic) and specific plate tectonic settings.
(*Clarification statement:* The plate tectonic settings to be considered here are continental collision, subduction zone, mid-ocean ridge, transformation fault, hot spot, and passive zone.)

e. Construct an argument using multiple forms of evidence that supports the theory of plate tectonics (e.g., fossils, paleomagnetism, seafloor age, etc.).

Additional notes on student supports

Performance Expectations for Instruction:

The GSE for Earth Systems requires that students continually develop and use models in order to better explain concepts across the various instructional segments. Students will also be provided models and asked to interpret and analyze data from these models that will further reinforce core concepts. In Earth Systems, models commonly consist of scaled and unscaled 2 and 3-dimensional surface and cross-sectional maps.

This lesson will utilize the mapping and modeling skills gained throughout the year to develop a visual of earthquakes around the world and the story earthquakes tell us about the structure of the Earth by answering what are earthquakes, why earthquakes happen, and where earthquakes happen.

Earthquakes are phenomena that are rare, but not unheard of, in Georgia. Students may not have a personal experience with earthquakes. Geologists and physicists use earthquakes to study the structure of the Earth. Students will explore this concept during this lesson.

The composition of the Earth explains the resulting processes that cause earthquakes and volcanoes. Students will evaluate the evidence for the development and composition of the Earth.

Materials
Computers/tablets
Access to the internet
Different colors of clay or blocks
Vellum paper for printing the tectonic plate overlay or some other thin tracing paper

Students will continuously obtain, evaluate, and communicate information. This is not a linear process. Students will communicate through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.

Engaging Learners	**Phenomenon** The students will view a video from the 2017 earthquake in Mexico. Students will start asking why, how, and what. Have students research the powerful 8.2-magnitude earthquake that rocked Mexico in 2017. To help answer why the plates move, have students research the Earth's internal heat budget and apply this concept in explanations throughout this segment.
	Obtaining Students obtain the location of the most recent earthquake in the world using an internet search. Several sites will give up to the minute earthquake information. *Teacher Notes: Resource: The Incorporated Research Institutions for Seismology provide such resources for educators in their Teachable Moments section. Teachers can sign up for presentations of information about earthquakes including location, seismology, and impacts shortly after the earthquake has occurred.* Have students Connect the Spheres to introduce and begin to ask questions about how the geosphere, hydrosphere, and atmosphere work together to make our Earth's systems.
	Evaluating Students should have a basic understanding that the earth's surface is composed of plates from middle school earth science. During the beginning of the segment, let students communicate their level of understanding through small group discussions on what has happened in Mexico geologically.

	Communicating Students model what happened in Mexico through a simple sketch or modeling the motion of the plates with blocks or clay. Have students identify the type of event. During the explanation, students should use evidence from world tectonic plate maps to explain why the plates are moving - energy from radioactive decay. *Teacher Notes: Students can use the most recent earthquake, but the earthquake may be so fresh that the type of quake has not been published. The ocean plate at the location of the 2017 Mexican earthquake is sliding under the North American continental plate.* Ask: What are the major plates and how do we know where they are located? Students can locate using longitudinal and latitudinal data and color code seismic activity related to earthquakes and volcanoes on a world map to discover the patterns or use resources that are already documented. A summary of how these plates were located can be found by researching: High School Earth Science Theory of Plate Tectonics An Explanation of Plate Margins Exploring Tectonic Motions Using GPS data Plate movements-- folds or faults are evident in earthquakes. Have your class take a virtual field trip to see examples of the results of folds and faults and their different movements. Have students use three colors of clay. Press each color into a flat rectangle and stack them. When pressure is added on each side, different folds and faults are evident. Have students work to produce each kind of major fault, sketch and label their findings or take pictures digitally to produce a presentation with explanations. *Teacher Notes: A Squeeze Box will give a more realistic view of the process. Research: How to Make a Squeeze Box* After research, have students use the Tectonic plate handout to write an explanation of why these landforms happen and what plate boundaries cause them. Students can make models using blocks or clay to show examples of where they occur. **Part 2** Show The Earth's Core and why it is so hot? Have students discuss the difference between the lithosphere and the asthenosphere. Another resource is Lithospheric Density , Differences between Crust and Lithosphere

Exploring	*Obtaining* Students will obtain data, make observations, and show evidence of what earthquakes are and why they happen by using the following video and simulations. **Magnitude 9.2: The 1964 Great Alaska Earthquake** • USGS Video of Earthquake • Shake, Rattle, and Roll: The Physics of Earthquakes-- Perspectives on Ocean Science • PHET Plate Tectonics Simulation (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu) *There are several teacher lessons provided in the PHET simulation. You can choose one or more that best match your students or develop your own.* Students will evaluate evidence for the development and composition and formation of the geosphere, hydrosphere, and the atmosphere.
	Communicating Students will communicate using evidence to support their explanation as to why earthquakes happen. They can research the following: • Structure and Composition of the Earth • Earth's Layers: Crust, Mantle, and Core • Video explaining the composition of the Earth: Structure of the Earth and its different layers Have students use these materials and others to evaluate the evidence for the development and composition of the Earth. Have them construct evaluations based on their research for theories and evidence to present to the class. *Students should understand the Earth's crust consist of plates that are moving. The role of radioactive decay as the source of energy that drives the process of convection is studied as part of this element.* **Part 2** Have students research "How does the Earth's core produce heat?" That the earth's core produces heat is one of the driving forces in the understanding of geological processes.
Explaining	**Phenomenon:** Have students work in small groups to find supporting evidence for the theory of plate tectonics; topics could be divided by group, such as continental drift, Pangea, fossils, paleomagnetism, seafloor age, etc. Have students work in small groups to find supporting evidence. Give each group a topic such as continental drift, Pangea, fossils, paleomagnetism, seafloor age, etc.

	Have them present their findings to the class. *Obtaining* 1. Students will obtain world maps. 2. Make sure students are working on the same size maps so that they can be reassembled at the end of this activity. 3. Place students in groups with each group given one of the following: North America (including Central America), South America, Asia, Europe, Africa, Australia, Antarctica and Arctic, Atlantic Ocean, Pacific Ocean, Indian Ocean.
	Evaluating Students will research earthquakes for at least the past twenty years if time allows for their respective locations and mark the locations on the maps. Students will research various websites that contains current and recent locations of earthquakes. Continue to use the Connect the Spheres lessons to complete the explaining and elaborating sections.
	Communicating The groups will present their maps. As a class, have students assemble their continent maps into a world map of earthquakes for the past 20 years. Then have the class produce a detailed map of the active faults around the world. **Part 2** Students will use this knowledge of how the core works to discuss with a partner how the mantle uses the heat from the core to cause the convection currents that move the mantle. Have students produce a label sketch (model) of the inside of the Earth labeling the layers to show how the movement happens.
Elaborating Applying Model to Solve a Problems	**Phenomenon** Students will view videos for the purpose of bringing the human aspect to the earthquakes. The students will develop a plan to protect people by knowing where earthquakes will happen and understand the efforts being made to know when. *Teacher Notes: Scientists do not have a complete understanding of when or where earthquakes will happen. Students who struggle with this lack of understanding could be encouraged to move into this area of science. They could be the one that helps understand the "when" of earthquakes.* **Students or teachers will research the following:** In Disaster Relief Information is Life & Death 5 Largest Earthquakes in History

	Obtaining and Evaluating *The "Mapping Earthquakes to Save the World" is an excellent activity to bring this instructional segment together. Teachers can develop their own lesson or utilize this activity that will lead students through mapping earthquakes and the significance of why the mapping is important.* Mapping Earthquakes to Save the World
	Communicating The students will communicate their understanding of earthquakes and plate tectonics by discussing where they would choose to live based on the fault maps developed earlier and the mapping earthquakes activity. Students should consider not just the faults, but also other phenomena that occur as a result of earthquakes, such as tsunamis. **Part 2** Students can then continue by extending their model to include how radioactive decay drives the process of convection.
Evaluation	***Assessment of Student Learning***
	Student explanations and examples of faults and folding Journals and other writing Mapping Skills Presentations on plate tectonics evidence Students will write an essay explaining how the four spheres work together. **Part 2** Students now need to put how the heating of the core affects the movement of the crust. They should be able to use information found in the lessons and construct an explanation for how this happens being sure to use the heat from the core, convection currents from the mantle and the brittle crust. Words like lithosphere and asthenosphere should also be used in this explanation.
SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	• Asking questions and defining problems. • Developing and using models • Constructing explanations • Engaging in argument from evidence • Obtaining, evaluating, and communicating information
Crosscutting Concepts	• Patterns • Cause and Effect

	• Systems and System Models • Stability and Change
Disciplinary Core Ideas	From *A Framework for K-12 Science Education*: • ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS • ESS2.A: EARTH MATERIALS AND SYSTEMS

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher should consider giving questions stems to the students.
2. The teacher should consider giving resources to students for students to use in their research.
3. The teacher should give students an organizer to record research, data, observations and questions.
4. Students may need additional time to complete their research.
5. The teacher should use flexible and intentional grouping. Best practice is to use data to group students.
6. The teacher may need to remind students what evidence is and how it can be used to support an

argument.
7. The teacher should provide an organizer for students to record sketching and explanations of what is occurring in the lab that the students are doing.
8. The teacher should consider giving sentence stems to students to help with constructing explanations.
9. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or verbally explaining.

Exploring:

1. The teacher should consider giving students a graphic organizer to record observations, data, research and begin writing their explanations.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or verbally explaining.
3. The teacher should consider giving resources to students for use as part of their research.
4. Students may need additional time to construct their evaluations.

Explaining:

1. The teacher should use intentional and flexible grouping. Best practice is to use data to group students.
2. The teacher should consider giving sources to students to use for their research.
3. The students may prefer to do a gallery walk rather than presenting their work to other students.
4. The teacher should have clear and consistent guidelines for students during presentations.
5. The teacher should consider giving students a rubric for the students to be able to evaluate their model. Self-evaluation is a tool to increase student ownership of their work.
6. Students may need additional time to complete their model and the class may need additional time to complete the large model.

Elaborating:

1. The teacher may need to show videos more than once to allow students to make adequate observations.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or verbally explaining.
3. Students made additional time to complete their explanation.

Evaluating:

1. The students may need additional time to construct their model.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or verbally explaining.

Tectonic movement and what they can make! Name _____

After researching these different types of landforms and seascapes describe what type(s) of tectonic plates made each and where is an example of each on Earth.

1. Continental collision

2. Subduction zone

3. Mid-ocean ridge

4. Transformation fault

5. Hotspot

6. Passive zone

7. Subduction zones

8. Rift zones

9. Ocean basins

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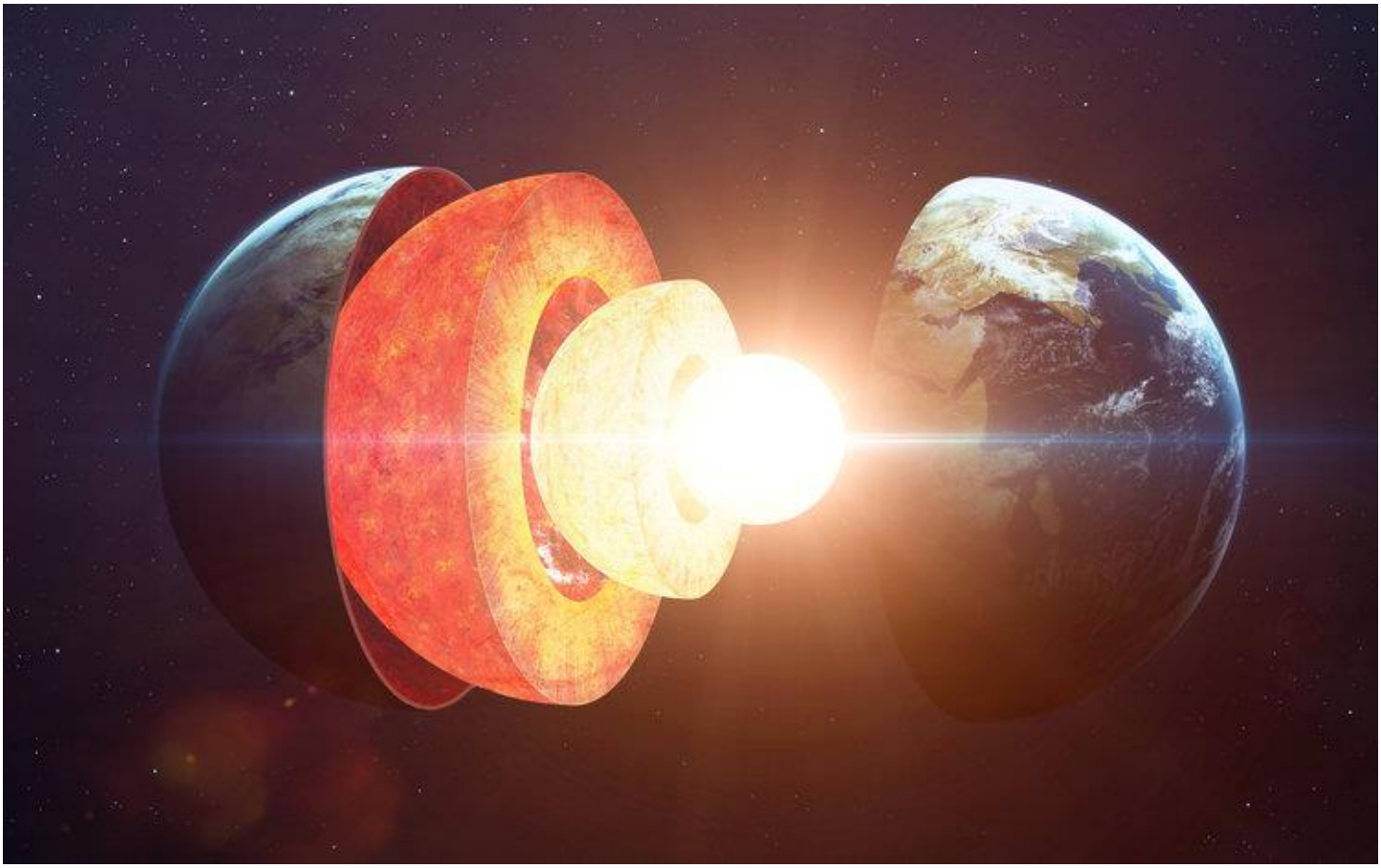
The Earth's Core and Why is it Hot?

Why does the Earth's score shine so brightly in this model?



How does the inner core affect the crust even though it is not near the crust?

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