

Energy and Matter 5E

Where is all the energy coming from to move plates apart from each other? What processes are occurring inside Earth that can cause it to reach Earth's surface? And why do people continue to live in these hazardous areas?

Performance Expectations

HS-ESS2-3,
HS-ESS2-1

Investigative Phenomenon

The Great Rift Valley is the cradle of humanity, but also experiences significant amounts of seismic activity from plates moving apart from each other.

Time

5-6 days

In this 5E instructional sequence, students are investigating the questions about the reasons for the movement of plates, such as *How does the Earth's interior move plates?* Students are also returning to the question *Why do people continue to live in hazardous areas?* This leads to questions about ways in which the heat energy powers plate tectonics and where heat energy comes from. Students use different kinds of evidence to arrive at conclusions about the processes that move plates and the way heat is generated inside the Earth, concluding that energy is being generated all over Earth's mantle and that models of convection further supports their understanding of how different areas of the Earth are at varying risk of earthquakes. This idea leads them to consider the types of matter that are moved by this energy, and determine that there are resource benefits to living at plate boundaries.

Engage	What is happening inside Earth that drives plate motion?	Students use what they know about Earth's interior to make initial claims about the source of energy that moves plates associated with the movement of matter observed in the Great Rift Valley.
Explore	How do differences in temperature affect matter inside the Earth lead to the movement of matter caused by the Tonga volcanic eruption?	Students develop and use a physical model that presents analog behavior for processes within Earth's interior in order to collect empirical evidence of patterns in movement of matter and energy .
Explain	How does plate motion occur?	Students develop an explanatory model for how energy inside the Earth drives the motion of tectonic plates on Earth's surface .
Elaborate	Why do people live in these hazardous areas?	Students evaluate evidence about the cycling of matter driven by the movement of energy in order to explain how resource availability has guided the development of human populations .
Evaluate	How does tectonic plate motion impact humans positively and negatively?	Students use what they learn about energy and matter flow in Earth's interior to model the energy and matter resources of tectonic plate boundaries and explain how tectonic activity impacts populations in both positive and negative ways .

Science & Engineering Practices

Disciplinary Core Ideas

Crosscutting Concepts

Engage

What is happening inside Earth that drives plate motion?

Students use what they know about **Earth's interior** to **make initial claims about** the **source of energy** that **moves plates** associated with the **movement of matter** observed in the Great Rift Valley.

Preparation

Student Grouping

None

Routines

☐ Rumors

Literacy Strategies

None

Materials

Handouts

☐ Energy Inside the Earth

Lab Supplies

None

Other Resources

☐ [The Great Rift Valley, Africa](#)

Launch and Surfacing Student Ideas

1. Remind students that one category of their questions that remains from the DQB is related to what is going on inside Earth that causes plate motion and in turn natural hazards and surface features. And that when they evaluated the theory of plate tectonics, they pointed out that the evidence that was presented was not yet supported by a mechanism for plate motion or for the production of energy that drives plate motion.
2. Reestablish that while they were able to use evidence from seismic waves, analysis of meteorites and volcanic eruptions to model Earth's interior structure and properties, they still do not know what process or mechanism is occurring inside Earth that drives plate motion and why the inside of Earth is so hot (contains so much energy).

Routine



The goal of the **Rumors** routine is to have students exchange ideas while listening for similarities and differences in thinking. It's meant to be low stakes, so it is frequently used to surface initial student ideas

3. Remind students also that we haven't figured out yet why people continue to live in these dangerous areas.
4. Tell students that they will now have the opportunity to observe an area on Earth where humans have been living for 100,000 years, which happens to also be in a place where tectonic plates are moving away from each other. By zooming in on this area, we will be able to get a better look at where energy is coming from to move these plates, and also take a look at some of the materials that are getting moved along with them in order to better understand why people live in these areas.
5. Provide students with the handout The Great Rift Valley and show them the video [The Great Rift Valley, Africa](#)
6. Have students consider the prompt: where do you think the energy to split this continent apart is coming from?
7. Use the group learning routine, **Rumors**, to support students in sharing their ideas about the energy source

about phenomena during the Engage phases. Please read the Earth & Space Science Course Guide for detailed steps about this routine.

Look & Listen For



- The heat from the Earth's interior boils over.
- Hot stuff rises because there's so much pressure and it bursts out at the surface
- The eruptions happen inside the Earth and make it all the way to the surface.
- Is the heat energy coming from the really hot part of the interior like the core or mantle?
- How does the heat from layers inside rise up so far to the Earth's surface?

8. Let students know that they will have the opportunity to explore these questions through this investigation.

Explore

How do differences in temperature affect matter inside the Earth lead to the movement of matter caused by the Tonga volcanic eruption?

Students **develop and use a physical model** that presents analog behavior for **processes within Earth's interior** in order to collect **empirical evidence of patterns** in **movement of matter and energy**.

Preparation

Student Grouping

- ☐ Table Groups

Routines

- ☐ Domino Discover

Literacy Strategies

None

Materials

Handouts

- ☐ Modeling Earth's Interior Processes
- ☐ Modeling Earth's Interior Processes

Lab Supplies

- ☐ Model 1: vegetable oil; beaker; hot plate; oregano
- ☐ Model 2: plastic tub; red and blue food coloring; water/ice
- ☐ Model 3: vegetable oil; casserole dish; tea candles; oregano; 4 plastic pieces (tectonic plates)

Other Resources

- ☐ [Model 1](#)
- ☐ [Model 2](#)
- ☐ [Model 3 - Top View](#)
- ☐ [Model 3 - Side View](#)

Launch

1. Remind students about their questions regarding whether the movement of matter observed in the Great Rift Valley was caused by the heat from the core or mantle and how it rises so far to reach the Earth's surface, and that during the last investigation they figured out that Earth's interior is divided into layers composed of different substances and that as you go deeper into the Earth, the temperature.

2. Tell students that they will be building on these ideas by modeling conditions with layers of different materials and increasing heat.

Investigation: Modeling Earth's Interior Processes

1. Provide each student with the *Modeling Earth's Interior Processes Investigation* handout.
2. Use conferring questions to push students' thinking about the investigation while they are collecting data.

Conferring Prompts



Confer with students during the investigation. Suggested during-lab conferring questions:

- When you initiated each model, where was the greatest amount of energy located?
- What did you notice about the movement of matter?
- What patterns did you observe related to matter (stuff) rising?
- What patterns did you observe related to matter (stuff) sinking?
- What effect do you think the heating and cooling has on the colored water and oil? Why does this affect its movement?
- What is happening to the plastic plates at the surface? What is causing that?
- How is the energy affecting the motion of matter?
- How might what you're observing explain the movement of matter observed in the Great Rift Valley.

Integrating Three Dimensions



Keep in mind, the Conferring Prompts are meant to support students in developing the idea that **energy drives the motion and/or cycling of matter within and between systems**, an important element of **CCC #5 Energy and Matter** at the high school level.

Investigation: Whole-Class Investigation Summary

1. Provide students with the *Modeling Earth's Interior Processes* Handout. Direct students to work independently to complete the See-Think-Wonder section, then use this completed table to discuss the findings from the investigation.
2. Ask groups to come up with one important idea to share with the whole class, from their See-Think-Wonder tables.
3. Use the group learning routine **Domino Discover** to surface important trends, inferences, and questions from groups' See-Think-Wonder sections. Plan forward based on the various understandings that students or student groups have articulated. It is appropriate to go onto the next phase once students

Routine



The **Domino Discover** is an opportunity to surface students' thinking to the whole class and the teacher. It allows students to learn from each other and for the teacher to assess whether

have had a chance to make sense of the data, and have had the opportunity to clarify what they have figured out about the investigative phenomenon under study in this learning sequence..

Look & Listen For



Possible student ideas and questions:

- When we initiated model 1, the greatest amount of energy was at the bottom of the beaker (hot plate).
- When we initiated model 2, the greatest amount of energy was in the red colored hot water in the bottle at the top.
- When we initiated model 3, the greatest amount of energy was at the middle of the bottom of the dish (candles).
- Stuff or matter was rising then sinking. I also saw the plastic plates in the middle move apart and crash into other plastic plates on the outside.
- Matter that was rising was initially hot or next to something hot (a high energy source).
- Matter that started sinking was not initially next to something hot or it was cool like the blue colored ice.
- I think that when the matter was next to an energy source and heated or was hot to begin with, it became or was less dense.
- I think that when the matter was not next to an energy source and cooled or cool to begin with, it became or was more dense.
- I know that more dense stuff sinks and displaces less dense stuff that is forced to rise. That might explain the rising and sinking we observed in all models.
- Heat from the models 1 and 3 moved from the bottom to the top - this might explain the eruption and the movement of matter caused by the Tonga volcanic eruption.
- The plates at the top of model 3 seemed to be moved apart by the oil that was rising in the middle and then crashed into the plates on the outside. This must be what is happening at divergent and convergent plate boundaries.
- Those plates moved toward other plates on the outside - this is like convergent plate boundaries where volcanoes form and erupt.

the class is ready to move to the next phase of instruction. Refer to the Earth & Space Science Course Guide for support with this routine.

Access for Multilingual Learners



Using **Domino Discover** at this stage provides support for multilingual learners who are **emerging** and **transitioning**. Providing different types of unique comprehensible input, all from peers in the classroom, supports students' language development. Refer to the Earth & Space Course Guide for more information on this routine.

5. If students don't surface any of the important observations named in the Look and Listen For, direct students back to appropriate investigation resources and use conferring questions to support them in making those observations before moving on, as they will be key to success in the Explain phase that follows.

Explain

How does plate motion occur?

Students **develop an explanatory model** for how **energy inside the Earth drives the motion** of **tectonic plates on Earth's surface**.

Preparation

Student Grouping

☐ Table Groups

Routines

☐ Class Consensus Discussion

Literacy Strategies

None

Materials

Handouts

- ☐ Explaining the Great Rift Valley
- ☐ Summary Task

Lab Supplies

None

Other Resources

Launch

1. Review all the student ideas that surfaced from the Explore phase and tell students that they are now going to bring all those ideas together to develop an explanatory model for what inside the Earth is causing plate motion associated with the movement of matter seen at plate boundaries.
2. Provide students with the handout, *Explaining the Great Rift Valley*. Tell students that they will first have an opportunity to make connections between the models they observed in the Explore and Earth's interior. Have students begin work in table groups on part 1 of the handout, pausing after they have made connections between the two models.
3. Review what parts of model 3 connect to the Earth's interior and how density is affected by temperature with the class. Students combine these two ideas to draw preliminary convection currents

Integrating Three Dimensions



In this unit students are developing proficiency with the **CCC#5 Energy and Matter**. This is an opportunity for students to build on their ideas that surfaced about energy and

combining their information about density and heat.

matter during the two previous investigations.

4. Prompt students to consider where the heat comes from. Ask students why they think the center of the Earth is so hot.
5. Regardless of their answers, leverage their prior knowledge to turn to the next part of the handout, *Where does the heat come from?* Support students as they read the text and diagram. Confer with students as they discuss in their table groups where the heat comes from.

Conferring Prompts



- Did we see any evidence of oxygen gas inside the Earth?
- Do we have evidence that the planet is hot enough to cause nuclear fusion?
- Which type of reaction could be creating heat in Earth's interior?

6. Take a moment to review with the class the key information they gained from the text.

Conferring Prompts



- Some of the heat in the mantle comes from residual heat from the creation of Earth, radiating out of the crust
- The rest of the energy comes from radioactive decay

7. Tell students that they will now combine all of that information into a complete explanatory model of energy inside Earth.

Developing and Explanatory Model

1. Remind students that they already created a simple model of convection in Earth's interior, but that they didn't include some of the components that we knew it should have had. The simple model showed Earth's core as one layer, but students know that it has two layers. That model also didn't include the new information they learned about energy being generated from radioactive decay in the mantle.
2. Remind students that we also never addressed where the energy came from to create Earth's magnetic field. Tell students that metal becomes magnetized when it is in motion. Remind them that we know

Integrating Three Dimensions

that the outer core is liquid metal, and that we already knew there was some motion in it because we knew that magnetic north moves. Ask them if, based on what they just learned, they can explain why the liquid metal in the outer core is moving.

Look & Listen For



- Convection currents in the outer core from residual heat radiating outwards are causing the movement of matter in the outer core

3. Remind students also that they have seen evidence that rocks are not evenly distributed throughout the crust and mantle. Ask them if they think radioactive decay is happening uniformly.

Look & Listen For



- Radioactive decay is likely not uniform throughout Earth's interior

4. Have students turn to part 2 of the handout, *Modeling the Movement of Energy and the Motion of the Great Rift Valley* and work in table groups to complete the model of the movement of Energy and the motion of the Great Rift Valley.
5. Confer with students as they develop their explanatory models.

Conferring Prompts

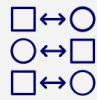


- What are the different parts of your model? Why did you include them?
- How do these parts of the system affect each other? How are you showing this?
- Where is energy driving the motion of matter? Where is the energy coming from?
- How is the energy causing matter to move?
- What is your evidence for what you included in the model?
- What science ideas support what you included in your model?



Keep in mind, the third Conferring Prompt is meant to support students in developing the idea that **energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems** and **energy drives the motion and/or cycling of matter within and between systems**, two important element of **CCC#5 Energy and Matter** at the high school level. The other Conferring Prompts are meant to support students in working toward proficiency with **developing models based on evidence to illustrate the relationships between systems or between components of a system**, an important high school element of **SEP#2 Developing & Using Models**.

Differentiation Point



Have students that have struggled with connecting multiple concepts to explain a phenomenon sit in one to two small groups. Sit with these groups and prompt them to draw arrows that show the motion of the olive oil in model 3 and how it leads to the plastic pieces moving apart. Then use probing questions to support students in applying relevant concepts to explain convection in model 3. Prompts may include:

- Where was the oil heated?
- What happens to the density of matter when it is heated?
- Does less dense matter rise or sink?
- What happens to matter as it moves further away from a heat source?
- How does the cooling of matter affect its density?
- Does more dense matter rise or sink?

As students respond to probing questions, have them annotate the diagram of model 3 to apply these concepts. After students have completed their annotations of model 3, have them individually transfer what they learned to the diagram of Earth's interior.

After they have modeled how convection happens in Earth's interior, have them refer to their models of how plate motion cause volcanic eruptions from the previous investigation, so they can incorporate those ideas and explain the movement of the Great Rift Valley.

Class Consensus Discussion

1. Orient the class to the purpose and the format of a class consensus discussion. You may say something like this:
 - "We are going to use a **class consensus discussion**, just like we did in the last 5E, to learn about all the thinking in the room and come to some conclusions about what processes inside Earth might be causing plate motion associated with the movement of matter seen in the Great Rift Valley."

Class Consensus Discussion Steps

1. we select a few different groups' ideas.
2. The first group shares out their work.

Routine



Class Consensus Discussions are so important for the Explain phase across this unit. This routine is a way to ensure that the accurate scientific ideas students are figuring out are made public and visible for all students to access. It requires skillful teacher facilitation, as it

3. One person repeats or reiterates what the first group shared.
4. Class members ask clarifying questions about the work.

Repeat steps 2-4 for each group that is sharing work.

5. Everyone confers in table groups.
6. Engage in whole-class discussion about the ideas that were shared, in order to come to agreement.

2. Select two or three student explanatory models to share with the class. At this point, do not select them randomly. The point of this discussion is to elevate ideas that move the class towards greater understanding of what processes inside Earth are causing Earth's plates to move. The decision about which models to share with the class should be based on both the ideas circulating in the classroom and the goals of this part of the 5E sequence.
3. Ask the first student or group to share their explanation. You can do this by:
 - Projecting using a document camera; OR
 - Copying the written explanation to be shared and passing them out to the class; OR
 - Taking a picture of each explanation and projecting them as slides.
4. Proceed through the steps in the Consensus Discussion Steps.
5. During the whole-class discussion, there will be opportunities to identify important terms and concepts that emerge in the discussion. Sometimes, important points get buried in student talk.

Take Time for These Key Points



Pause the discussion and ask for clarification, particularly of the following key points:

- There are differences in temperature in Earth's interior which cause differences in density of the matter inside Earth.
- The temperature is highest in the core, so it transfers heat to the mantle which is lower in temperature.
- When mantle rock is heated by the core, it expands and becomes less dense.
- Lower temperature rock that is more dense is pulled down by gravity and forces the hotter less dense rock up.

is important to not tell students what they need to know, instead supporting students as a class in using the information they have from investigations, their models and texts in order to figure out and state those important ideas. Please read the Earth & Space Science Course Guide for detailed steps of this routine.

Integrating Three Dimensions



The depth of this discussion will really depend on what you've observed in the room and how you respond. Be sure to make **CCC #2 - Energy and Matter** explicit for students by elevating and probing for ideas related to the concept that **energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems and energy drives the motion and/or cycling of matter within and between systems.**

- When the hotter less dense rock is forced up close to Earth's surface it can come out as new crust at divergent plate boundaries, which drives those plates toward convergent plate boundaries with another plate.
- As rock rises and gets closer to Earth's surface it cools because it transfers heat to the cooler surroundings and becomes more dense. Gravity then causes it to start sinking and be part of the cycle of sinking and rising rock in Earth's mantle that forces Earth's massive plates to move and cause natural hazards and surface features.

6. Return to student questions that bring up lingering issues not yet resolved, such as:

- Why is Earth's interior so hot? Why is there so much energy inside Earth? Where is the energy coming from?

Summary

1. Students individually complete the *Summary Task*. This can be completed as an exit ticket or for homework.
2. The results of this task can be used to make determinations about which students need more time to engage in sense-making about what processes inside Earth are causing Earth's plates to move.

Implementation Tip



This summary is really important! It's an opportunity to check in on each student's thinking at this point in the unit, in a few different areas: 1) **understanding how they are using the three dimensions, including the concept of natural selection, to make sense of a phenomenon** 2) ideas about how they and their peers are building knowledge together; 3) how they think the class consensus discussion went. It's important to get all of this from individual students, so you know these things on a student-by-student basis.

Elaborate

Why do people live in these hazardous areas?

Students **evaluate evidence** about the **cycling of matter driven by the movement of energy** in order to **explain how resource availability has guided the development of human populations**.

Preparation

Student Grouping

☐ Table Groups

Routines

☐ Read-Generate-Sort-Solve

Literacy Strategies

None

Materials

Handouts

- ☐ How do energy and minerals impact human populations?
- ☐ Minerals, Energy, and Human Populations

Lab Supplies

None

Other Resources

☐ [World Population History](#)

Evaluating Evidence

1. Remind students about their questions about why populations have been living in hazardous areas for thousands of years.
2. Tell students that this pattern goes back long in history. Show students the interactive [World Population History](#) (it will play as a video if you press the play icon on the bottom left where it says Animate Map and Timeline). Point out to students that, up until about 1500, when colonialism increased, most societies were living along areas that we know now to be tectonically active.
3. Provide each student with the handout, *How do energy and minerals impact human populations?* and the

Routine



The **Read-Generate-Sort-Solve** routine promotes collaborative engagement in problem-solving and supports students in articulating their thinking and

Minerals, Energy, and Human Populations.

4. Ask students to independently complete the Generate section based on the data tables and science ideas found on their handout.
5. After students have had the opportunity to view the data and generate ideas, use the Group Learning Routine, **Read-Generate-Sort-Solve** to facilitate student collaboration as they develop responses to the guiding prompts.
 - How has resource availability guided the development of human populations and societies?
 - Why do people live in these areas?
6. Have various groups share their responses to the two guiding prompts.

Look & Listen For



Possible student ideas and questions:

- Tectonic plate boundaries have resources that are beneficial to human populations
- The circulation of hot fluids concentrates trace elements, so these areas have precious metals and gems
- Tectonically active areas have diverse landscapes
- Volcanic areas have fertile soil
- Tectonically active areas are often near coasts or other bodies of water

making it transparent, before considering solutions. Please read the Earth & Space Science Course Guide for detailed steps of this routine.

Access for All Learners



Read-Generate-Sort-Solve is an important routine because it builds in individual think time and opportunities for all students to contribute to the group answer. Students who need additional processing time, or a chance to adjust their thinking after hearing from peers, get that opportunity. This additional time for language input is especially helpful for **emerging language learners**.

Evaluate

How does tectonic plate motion impact humans positively and negatively?

Students use what they learn about **energy and matter flow in Earth's interior** to **model** the **energy and matter resources** of tectonic plate boundaries and **explain** how tectonic activity **impacts populations in both positive and negative ways**.

Preparation

Student Grouping

- ☐ Independent
- ☐ Table Groups

Routines

None

Literacy Strategies

None

Materials

Handouts

- ☐ Tectonically Active Region Resources
- ☐ Energy Transfer Model Rubric
- ☐ Energy and Matter Explanation Rubric
- ☐ Revisit the Performance Task: Energy and Matter

Lab Supplies

None

Other Resources

Revisit the Performance Task

1. Provide students with *Tectonically Active Region Resources*
2. Have students talk in groups about the resources found in each region of focus
3. When students are ready, have them turn to the performance task organizer and independently construct their models and explanations.

4. Confer with students while they are working.

Conferring Prompts



Confer with students as they work to develop their arguments. Prompt students to return to the class wide scientific argument characteristics, posted in the room.

Suggested conferring questions:

- What evidence did you generate in this 5E sequence?
- Where did the evidence come from?
- How well does that evidence support the claim?
- What ideas or contradictory evidence weaken the claim?

Standards in Energy and Matter 5E

Performance Expectations

HS-ESS2-1 **Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.**

Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).

Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.

In NYS the clarification statement and assessment boundary have been edited as follows: Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and deposition) and destructive processes (such as weathering, subduction, and coastal erosion). Assessment Boundary: Assessment does not include recalling the details of the formation of specific geographic features of Earth's surface.

HS-ESS2-3 **Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**

Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

Assessment Boundary: None

In NYS the clarification statement has been edited as follows: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Rocks and minerals can be identified and classified using various tests and protocols that determine their physical and chemical properties. Examples of evidence could include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

Aspects of Three-Dimensional Learning

Science and Engineering Practices

Disciplinary Core Ideas

Crosscutting Concepts

Developing and Using Models

- Develop, revise, and/or use a model based

ESS2.A Earth Materials and Systems

- Evidence from deep probes and seismic

Cause and Effect

- Empirical evidence is required to

Science and Engineering Practices

Disciplinary Core Ideas

Crosscutting Concepts

on evidence to illustrate and/or predict the relationships between systems or between components of a system. SEP2(3)

Constructing Explanations and Designing Solutions

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. SEP6(2)

waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. ESS2.A(2)

ESS2.B Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. ESS2.B(1)

ESS3.A Natural Resources

- Resource availability has guided the development of human society. ESS3.A(1)

ESS3.B Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. ESS3.B(1)

differentiate between cause and correlation and make claims about specific causes and effects. CCC2(1)

Energy and Matter

- Energy drives the cycling of matter within and between systems. CCC5(4)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. CCC7(2)
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Assessment Matrix

	Engage	Explore	Explain	Elaborate	Evaluate
Developing and Using Models		<i>Modeling Earth's Interior Processes</i>			<i>Revisit the Performance Task: Energy and Matter</i>
Constructing Explanations and Designing Solutions			<i>Explaining the Great Rift Valley</i> [material: ESS.U3.L3.Explain.H2]	<i>How do energy and minerals impact human populations?</i>	<i>Revisit the Performance Task: Energy and Matter</i>
ESS2.A Earth Materials and Systems	<i>Energy Inside the Earth</i>	<i>Modeling Earth's Interior Processes</i>	<i>Explaining the Great Rift Valley</i> [material: ESS.U3.L3.Explain.H2]		<i>Revisit the Performance Task: Energy and Matter</i>
ESS2.B Plate Tectonics and Large-Scale System Interactions			<i>Explaining the Great Rift Valley</i>		<i>Revisit the Performance Task: Energy and Matter</i>
ESS3.A Natural Resources				<i>How do energy and minerals impact human populations?</i>	<i>Revisit the Performance Task: Energy and Matter</i>
ESS3.B Natural Hazards				<i>How do energy and minerals impact human populations?</i>	<i>Revisit the Performance Task: Energy and Matter</i>
Cause and Effect				<i>How do energy and minerals impact human populations?</i>	
Energy and Matter	<i>Energy Inside the Earth</i>	<i>Modeling Earth's Interior Processes</i>	<i>Explaining the Great Rift Valley</i> [material: ESS.U3.L3.Explain.H2]		<i>Revisit the Performance Task: Energy and Matter</i>

	Engage	Explore	Explain	Elaborate	Evaluate
Stability and Change					Revisit the Performance Task: Energy and Matter

Common Core State Standards Connections

	Engage	Explore	Explain	Elaborate	Evaluate
Mathematics		MP2 MP3 MP4 MP6		MP2 MP3 MP4 MP6	
ELA/Literacy		WHST.9-10.9	WHST.9-10.1 WHST.9-10.5 SL.9-10.4	WHST.9-10.9	WHST.9-10.1 WHST.9-10.9