Lesson 1: What is happening in the Afar region?

Previous Lesson *There is no previous lesson.*

This Lesson

Anchoring Phenomenon

2.5 days

Asfawossen Asrat, 2005

We explore a StoryMap about the Afar region, presenting a strange series of events in 2005 that left a giant crack in Earth's crust. We connect to prior experiences with earthquakes and explore maps of earthquakes. We read about historic North American earthquakes. We ask our communities about their earthquake experiences. We compare the North American cases with Afar and develop initial models for before, during, and after earthquakes. We develop questions for our Driving Question Board and ideas for investigations.

Next Lesson *We will analyze plate motion data and develop a physical model to identify force interactions between plates. We will carry out investigations of the conditions that result in stability and change in an object's motion when multiple forces act on it. We will use free-body diagrams to explain and predict how the magnitude of forces at different scales impacts stability and changes in the matter within the system.*

BUILDING TOWARD NGSS

HS-PS1-8, HS-ESS1-5, HS-ESS2-1, HS-ESS2-3

What students will do

1.A Develop a diagrammatic model of relationships between Earth systems to explain what causes land to crack, break, and move, and to predict what will happen to the land in the Afar region in the future. (SEP: 2.3; CCC: 2.2; DCI: ESS2.B)

1.B Ask questions about the mechanisms driving changes in Earth's crust that arise from careful observation of patterns in the Afar region, in order to seek additional information from indirect evidence because aspects of the phenomenon are too slow and too large to study directly. (SEP: 1.1; CCC: 3.2, 3.3; DCI: ESS2.B)

What students will figure out

- A crack opened up in Earth's crust in 2005 in a region called Afar.

- Earthquakes seem to happen mostly along plate boundaries, but some happen in the middle of plates. They all seem to be connected to faults.
- Earthquakes happen underground and can cause cracking and moving of Earth's surface.

Lesson 1 • Learning Plan Snapshot

Part	Duration		Summary	Slide	Materials
1	5 min		**NAVIGATE** Introduce students to a new phenomenon and motivate the need to further explore it.	A-B	
2	10 min		**EXPLORE THE AFAR EARTHQUAKE** Share the StoryMap about the Afar region, and complete a Notice and Wonder chart.	C-D	https://arcg.is/1mWzu9, Afar Noticings and Wonderings poster, chart paper markers
3	3 min		**ELICIT PRIOR KNOWLEDGE ABOUT EARTHQUAKES** Uncover student ideas around why earthquakes happen on plate boundaries, and why it is unusual for them to happen elsewhere.	E-F	
4	8 min		**EXPLORE A MAP OF EARTHQUAKES** Look for patterns of earthquakes to try to determine whether the Afar events could happen in the United States.	G-I	https://www.openscied.org/general/earthquake-volcano-map/
5	7 min		**READ ABOUT OTHER EARTHQUAKE CASES** Read earthquake cases in small groups, and compare information from these cases to Afar.	J	*Case Comparisons*, https://arcg.is/0KC4ai (optional), *Earthquake Cases*, Afar Noticings and Wonderings poster
6	10 min		**JIGSAW THE EARTHQUAKE CASE READINGS** Discuss the earthquake case readings in small groups and complete Steps 2-3 of the *Case Comparisons*.	K	*Case Comparisons*, https://arcg.is/0KC4ai (optional), *Earthquake Cases*
7	2 min		**NAVIGATE: ASSIGN HOME LEARNING** Introduce the home learning assignment of collecting earthquake stories from the community.	L	
					End of day 1
8	4 min		**NAVIGATE: SHARE EXPERIENCES OF RELATED EARTH PHENOMENA** Share related experiences from the home learning assignment and compare them with Afar.	M	*World Map*, 3x3 sticky notes, Community Agreements poster
9	10 min		**REVISIT AFAR AND SHARE PATTERNS IN EARTHQUAKE CASE READINGS**	N-P	*Case Comparisons*, https://arcg.is/0KC4ai (optional), *Earthquake Cases*, Afar

			In small groups, review noticings and wonderings about Afar. Compare Afar with other earthquake cases, and complete Step 3 of the *Case Comparisons*. Conduct an Initial Ideas Discussion.		Noticings and Wonderings poster, dry erase marker
10	8 min		**DEVELOP AN INITIAL MODEL FOR AFAR AND OTHER EARTHQUAKES** Develop an initial model to show what happens before, during, and after an earthquake at Afar and the other earthquake cases. Compare models in pairs.	Q-R	*Case Comparisons*, *Initial Afar Models*
11	5 min		**REVISIT OUR COMMUNITY AGREEMENTS** Reflect on strategies for supporting our Community Agreements. Then review these strategies as a class.	S	Community Agreements poster
12	7 min		**DEVELOP AN INITIAL CONSENSUS MODEL FOR AFAR** Develop an initial consensus model in a Scientists Circle to show what is happening under Afar that could cause the observable changes on the surface.	T	*Initial Afar Models*, Initial Consensus Model for Explaining Changes in the Afar Region poster, chart paper markers
13	6 min		**INTRODUCE AND USE THE SCALE CHART POSTER** Consider the temporal and spatial scales of the events at Afar, and record these on the Scale Chart poster.	U	Scale Chart poster, Initial Consensus Model for Explaining Changes in the Afar Region poster, 3x5 sticky notes, permanent marker
14	5 min		**NAVIGATE: DEVELOP AN INITIAL CONSENSUS MODEL FOR OTHER CASES** On the initial consensus model, document how other earthquake cases might have occurred, and what might make them similar to and different from Afar.	V	*Case Comparisons*, https://arcg.is/0KC4ai (optional), Initial Consensus Model for Explaining Changes in the Afar Region poster, chart paper markers, whiteboard, Scale Chart poster, 3x5 sticky notes, permanent marker

End of day 2

15	15 min		**NAVIGATE: BUILD THE DRIVING QUESTION BOARD** Develop questions for the Driving Question Board. Join in a Scientists Circle to add the questions to the DQB.	W-X	3x3 sticky notes, permanent marker (dark), Afar Noticings and Wonderings poster, Initial Consensus Model for Explaining Changes in the Afar Region poster, Community Agreements poster, Driving Question Board

16	3 min	**REFLECT ON OUR USE OF COMMUNITY AGREEMENTS** Look back at the Community Agreements and consider whether any revisions need to be made.	Y	sticky dot (green), sticky dot (yellow), Community Agreements poster
17	5 min	**BRAINSTORM INVESTIGATION IDEAS** Develop ideas for investigation. Consider whether any potential causes for the earthquakes are operational before the earthquakes occur.	Z-AA	Driving Question Board, Ideas for Investigations/Data We Need, chart paper markers

End of day 3

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • https://arcg.is/1mWzu9 • https://www.openscied.org/general/earthquake-volcano-map/ • *Case Comparisons* • https://arcg.is/0KC4ai (optional) • *Initial Afar Models* • 3x3 sticky notes • permanent marker (dark) • sticky dot (green) • sticky dot (yellow)	• *Earthquake Cases*	• Afar Noticings and Wonderings poster • chart paper markers • *World Map* • 3x3 sticky notes • Community Agreements poster • dry erase marker • Initial Consensus Model for Explaining Changes in the Afar Region poster • Scale Chart poster • 3x5 sticky notes • permanent marker • whiteboard • Driving Question Board • Ideas for Investigations/Data We Need

Materials preparation (20 min minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Three-hole-punch all handouts so they can be added to students' science notebooks.

Make copies of the handouts for this lesson:

- *Case Comparisons* - 1 per student

- *Initial Afar Models* - 1 per student
- *Earthquake Cases* - 1 for each group of 5-6 students

Prepare chart paper for the posters you will make in this lesson:

- Afar Noticings and Wonderings
- Initial Consensus Model for Explaining Changes in the Afar Region
- Scale Chart
- Driving Question Board
- Ideas for Investigations/Data We Need

Make sure the Community Agreements poster, developed in *OpenSciEd Unit P.1: How can we design more reliable systems to meet our communities' energy needs? (Electricity Unit)*, is readily visible in the classroom. If you and your students have not yet co-developed these agreements, see the *OpenSciEd Teacher Handbook: High School Science* for guidelines.

Test the 3 student links:

- **A Sudden Crack in Ethiopia:** https://arcg.is/1mWzu9
- **Earthquake Cases Storymap:** https://arcg.is/0KC4ai
- **Earthquake and Volcanism Map:** https://www.openscied.org/general/earthquake-volcano-map/

Watch https://youtu.be/PkorK9_yEj8 to learn how to use the Earthquake and Volcanism Map features, and watch https://youtu.be/KeS_Bk_kwuw to learn about how to use the Earthquake Cases Storymap.

This lesson utilizes earthquake cases from several locations across the United States and elsewhere in North America; however, earthquakes occur in many other places in this region. Consider creating a more localized case, using the *Local Case Creation* reference, for students to investigate. Add your localized case to the *Case Comparisons* handout.

Use the image on the *World Map* reference (or a similar world map) to create a space for students to record their earthquake experiences. For example, consider either scaling up the image and printing a copy on 11x17 copy paper, or creating a jamboard and using the image as a background.

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

Because this is the first lesson in a new unit, the goal is not to establish any ideas associated with the relevant disciplinary core idea (DCI, ESS2.B), but rather to get student ideas related to that DCI on the table. Therefore, we do not specify which element of this DCI is being addressed. Students will have ideas about volcanoes, earthquakes, mountains, and so forth. Some may bring in ideas about mantle convection and plate tectonics. Accept all ideas without judgment right now, even if they are scientifically inaccurate.

If a student shares an idea that feels very inaccurate, you can respond for now with one of the following:

- *Wow, that's an interesting idea! Does anybody disagree?*
- *Let's follow up on that for sure. How could we investigate the claim _____ made? Let's add it to our ideas for investigations later.*
- *What an interesting idea. Could you reframe it as a question for our Driving Question Board?*

In this lesson, it is important for students to recognize that parts of the African continent are moving in different directions at different velocities. This leads them to wonder what is happening beneath the surface to cause changes like the 2005 crack in Afar, motivating the need to look at the forces acting on this part of Earth's crust.

Similarly, some student engagement with the science and engineering practice (SEP) and crosscutting concept (CCC) elements in this lesson may not reach grade-band level. That is OK, as the lack of DCI mastery may limit their access to full engagement. Assessment in this lesson should be used formatively.

The CCC of *scale, proportion, and quantity* is essential to this unit, and its elements 3.2 and 3.3 are introduced in this lesson. These and other elements will be intentionally developed across multiple lessons. The Scale Chart poster, which will be revisited across the unit, is one representation meant to scaffold students' thinking. In this lesson, only a spatial scale is included on the chart; a temporal scale will be added in Lesson 2.

Students may not know what a tectonic plate is at this point, and that is OK. If they ask, say it is a great question to put on the DQB, or allow other students to suggest a meaning. You will co-develop a meaning for what a plate is over the next several lessons, and encounter a formal definition in Lesson 5. We recommend that you **do not** post any terms or ask students to record any words until after your class has developed a shared understanding of their meaning.

In this lesson, students also have the opportunity to share their own experiences related to earthquakes. Keep in mind that although some might readily share, not all may want to, and some experiences could be difficult to retell or relive. Do not require anyone to share, and do not press if students do not want to. In addition, make sure to provide a space for students who do not want to hear about others' earthquake experiences.

Before the unit starts, reach out to students' support systems at home using the Pre-Unit Letter Home. This letter is a way to communicate with trusted adults and make them aware of the unit's content, such as earthquakes. It also gives them an opportunity to share important context with you about students' experiences and background that might be relevant.

This lesson's topic can be sensitive for those who have experienced injury, trauma, or loss due to earthquakes. Please be mindful of this and provide safety and support by sharing awareness. If there is time, consider starting the class period with a brief mindfulness activity; see the Afar SEL Supports reference for suggestions.

Consider beginning the unit by saying: *As we work through this unit, be mindful of any impact you're noticing within yourself based on your own personal experiences. The events we're going to study do impact people every day. If you need to talk, process, or regain some grounding in the here and now, please let me or the school counselor know.*

Be aware that students who are struggling may demonstrate various behaviors including but not limited to: fidgeting, withdrawal, disruption/distraction, rapid breathing, holding their breath, and change in body language or tonation. If you notice a student may be struggling, share what you are observing and ask whether they need some help.

Where We Are NOT Going

Students who had instruction aligned with Next Generation Science Standards (NGSS) in middle school may have learned about the creation of continental and ocean floor features by plate interactions (MS-ESS2-3), such as two plates converging to form mountains. The high school level focus is less about explaining specific surface features and more about how the motion and forces causing them are an expression of mechanisms related to changes in the matter, energy, and forces responsible for mantle convection.

We intentionally avoid naming the structures and properties of Earth's interior in this lesson, as these will be explored in future lessons.

LEARNING PLAN for LESSON 1

1 · NAVIGATE

5 min

MATERIALS: None

Exploring a new phenomenon. Present **slide A**. Read the summary on the slide:

- *In October 2005, people in northeast Africa took this photo of a huge crack in the ground that was not there before.*

Point out that the left side of the photo shows a series of people standing along the side of the crack, giving us a sense of its spatial scale. Pose the question on the slide to elicit initial ideas about this phenomenon, as shown in the table below.

Suggested prompt	Sample student response
What might have caused this change in Earth's surface?	An earthquake. Erosion, water. The ground shook and broke open. Plate tectonics, faults.

Say, *It sounds like we have a lot of ideas about why this crack might have occurred!*

Briefly consider what data might be helpful. Present **slide B**. Ask, *If we want to understand why this happened, what would you like to know more about, related to this event and the area where it occurred?* Accept all ideas, listening for students to suggest that they want to know whether anybody was injured, whether there are earthquakes in the area, weather-related reports, plate maps, or if any of the things they just suggested possibly caused the event. Take only 1-3 ideas and move on quickly.

Say, *It sounds like we have some initial ideas and want to know more about the region. I have a tool that tells the story of what happened in 2005, and it allows us to look at the region surrounding the event. This may provide some of the information we're looking for to help us dig deeper into these phenomena.*

2 · EXPLORE THE AFAR EARTHQUAKE

10 min

MATERIALS: science notebook, https://arcg.is/1mWzu9, Afar Noticings and Wonderings poster, chart paper markers

Set up the science notebook. Display **slide C**. Give students a moment to prepare a T-chart like the one on the slide. They can do this directly in their notebooks or on loose-leaf paper to add to it.

Share the StoryMap link. Distribute computers to students and share https://arcg.is/1mWzu9 . It is recommended to have students access this StoryMap individually, but groups of 2-3 are also an option. Instruct them to read through the StoryMap, which has information about what happened in the Afar region in 2005, and to record what they notice and wonder on their T-chart.

Facilitate an Initial Ideas Discussion. Display **slide D**. On the Afar Noticings and Wonderings poster, create a T-chart to mirror the students' T-chart. Invite students to share aloud what they noticed and wondered. ✱ As they share, quickly document their ideas on the poster.

KEY IDEAS

Purpose of this discussion: To collect students' observations and questions about the data they have seen so far, to then motivate looking at additional data. This is not the time to critique ideas or push for evidence.

Listen for these ideas:

- There was a volcanic eruption.
- There were lots of earthquakes/aftershocks before and after the crack was formed.
- The crack is not located at a plate boundary.
- The earthquakes occurred on fault lines.
- The land is really low in this part of the world (below sea level).
- The land to the left and right of the crack moved in different directions and changed in elevation.
- People generally feel earthquakes over a magnitude of 4.

Potential questions students could ask:

- Did the volcano's eruption cause the crack?
- How long will this keep going on?
- What is a fault line?
- Does this only happen in the desert, because the land was dried out?
- Can this happen where I live?
- How do earthquakes happen at places that are not on plate boundaries?

✱ STRATEGIES FOR THIS INITIAL IDEAS DISCUSSION

For each discussion type, the teacher takes a different stance in facilitation. Be explicit about your role in this Initial Ideas Discussion. Your role is to capture all student ideas, build excitement, and encourage as many students as possible to participate, whether the ideas they share are right or wrong.

Make space for all students to share ideas (possibly connected to experiences outside school as well). Encourage student-to-student talk with a focus on raising questions, clarifying, or adding to what someone has said, rather than debating or arguing. They may also use nods or hand signals to show they had a similar idea.

3 · ELICIT PRIOR KNOWLEDGE ABOUT EARTHQUAKES

3 min

MATERIALS: None

Elicit experiences with related events. Project **slide E**. Say, *We just learned that the people in Afar experienced several phenomena--earthquakes, a volcanic eruption, and a giant crack in the ground. Do any of you have experience with those phenomena?*

Ask for a show of hands for each phenomenon to elicit generally whether students have had experiences with them. Some may have experienced all three, but most are likely to have seen or heard of earthquakes, perhaps some with cracks in the ground.

Motivate looking deeper into earthquakes. Point out that it seems the class has more experience with earthquakes than the other phenomena. Suggest that in looking for the cause of this giant crack in Afar, we start with earthquakes, because they are more familiar. If students want to share specific stories of their experiences, assure them they will have a chance to do so later in the lesson.

Consider why earthquakes might occur. Project **slide F**. Use the slide's questions to problematize:

- *What do we know about earthquakes that might cause them to happen in some places but not others?*
- *Can earthquakes happen anywhere, even at non-plate boundaries?*

Allow students to share their ideas regarding where earthquakes generally occur and why. Here are a few possible ideas and questions to listen for and probe for details:

- Most earthquakes happen on plate boundaries.
- The earthquakes in Afar happened around the time a volcano erupted. Are volcanoes and earthquakes related?
- Earthquakes are related to plate motion.

4 · EXPLORE A MAP OF EARTHQUAKES

8 min

MATERIALS: science notebook, https://www.openscied.org/general/earthquake-volcano-map/

Introduce the idea of earthquake patterns and scale. Explain that we can look at a map showing earthquakes and plate boundaries to see whether earthquakes are happening at unexpected places. We can also look for patterns related to earthquakes that might help explain the events at Afar.

Display **slide G**. Pose the slide's prompts:

- *What patterns might we notice when looking at any potential earthquakes?*

✱ ATTENDING TO EQUITY

Universal Design for Learning: The colors of this map were intentionally chosen to

- *At what scale might we see those patterns?*

Ask students to share their answers. Accept all potential patterns, including the idea that earthquakes might occur in lines or clusters on plate boundaries, as well as other patterns that make sense from a student's perspective.

Identify potential earthquake patterns and scale. Present **slide H**. Tell students to take 5 minutes to individually look at the map and generate a list of potential patterns they notice, as well as any noticings and wonderings, in their notebooks. Share the map using the link on the slide: https://www.openscied.org/general/earthquake-volcano-map/ . ✱ Ask students to consider the first three questions as they work:

- *Do earthquakes happen in our region?*
- *What patterns do you notice?*
- *At what scale are these patterns?*

ADDITIONAL GUIDANCE

If students have never used a web app like this, it may be beneficial to take some time to walk them through the map's features. Show https://youtu.be/PkorK9_yEj8 for an explanation of the useful features, or share this video with students as needed.

If students finish early, ask them to consider the last question on the slide:

- *Why might we expect earthquakes to happen in some places but not others?*

Bring the class back together and have students share their answers to the first three questions.

KEY IDEAS

Purpose of this discussion: Establish any patterns of earthquakes that students see, and work toward considering what is causing these patterns.

Listen for these ideas:

- Though some earthquakes appear to be isolated events, earthquakes are generally grouped in lines or clusters.
- These lines and/or clusters are also present in Afar in the region of the 2005 earthquake.
- There are a lot more earthquakes on plate boundaries than other places, but earthquakes do occur in lines and/or clusters in other regions away from plate boundaries.

Use questions like these to push student thinking:

increase accessibility for color-blind students.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY

In this unit, students will use extensive scale thinking. It is important to scaffold their understanding of different scales early. If they struggle with understanding what is meant by patterns being observable at one scale but not another, zoom in and out on the map to various scales at different locations to show that some clusters and lines are only observable at a particular scale. If the zoom is too close, the earthquake pattern may not be visible, and if the zoom is too far out, the pattern may also not be visible.

If students struggle to understand what is meant by scale in general, talk about how scales describe how things vary in size or time span. Point out the scale key on the map's lower left corner, and how the numbers change when you zoom in and out. Note that this is a scale representation using a ratio between distance on the map and distance on Earth. Scale thinking often involves comparing relative sizes or time spans and what can be observed at the scale being used.

- *Why do you think these earthquakes might be in lines or clusters?*
- *What is the scale of the lines or clusters of earthquakes?*
- *Do earthquakes only happen on plate boundaries?*
- *Why might earthquakes happen primarily at plate boundaries? What could be causing the other earthquakes that are not at plate boundaries?*
- *For the patterns we've identified that are similar to Afar, what might we see on the surface after these earthquakes?*

Determine the scale at a plate boundary. Display https://www.openscied.org/general/earthquake-volcano-map/ . Students should notice that they do not need to zoom in on the west coast and other plate boundaries to see earthquake patterns in lines; these earthquakes are clustered along a plate boundary, with many on this line.

Determine the scale of the lines of earthquakes. Display **slide I**. Pose the first prompt:

- *Do you think all earthquake lines or clusters are visible at the same scale?*

Have the class choose a particular set of lines or clusters that are **not** on a plate boundary, such as the lines in the southeast corner of Missouri. Display these on the map. Ask students at what scale they began to see the line or cluster that seems to be a pattern for most earthquakes. Guide them to determine that some patterns are more visible at different scales. ✱

Pose the second prompt:

- *Why might we expect earthquakes to happen in some places but not others?*

Allow students a moment to reflect quietly before sharing out. They might say it makes sense for an earthquake to happen on a plate boundary because the plate is moving, but plates are not colliding or sliding past each other in the middle of the United States. Listen for and use any ideas about why earthquakes are expected in some regions and not others to move into the slide's third prompt:

- *How might these earthquakes that are not located at plate boundaries be similar to or different from what occurred in Afar?*

Accept all responses. Then tell the class these earthquakes were puzzling to you as well, so you have collected some earthquake cases from various parts of North America to learn more about how and why these might also be occurring, and whether they are similar to the Afar earthquakes.

5 · READ ABOUT OTHER EARTHQUAKE CASES

7 min

MATERIALS: *Case Comparisons*, https://arcg.is/OKC4ai (optional), *Earthquake Cases*, Afar Noticings and Wonderings poster

Read about earthquakes. Present **slide J**. Assign students to groups of 5, or groups of 6 if you created an earthquake case using the *Local Case Creation* reference. Explain that each student in the group will read a different earthquake story. ✱

Distribute the *Case Comparisons* handout to each student and the *Earthquake Cases* handout to each group. Have each student select a case to read. ✱ ✱ In lieu of using the *Earthquake Cases* handout, they can access the information as a digital StoryMap at https://arcg.is/OKC4ai .

ADDITIONAL GUIDANCE

If the class is not easily divisible by 5 (or by 6 if a local case was added), make sure any smaller groups at least read about an earthquake at a plate boundary (e.g., San Francisco) and an earthquake closer to your location.

In addition, if students are using the StoryMap but have not seen one of this style, cue them on how to view multiple pictures associated with each earthquake case. For information about how to use this StoryMap, see https://youtu.be/KeS_Bk_kwuw .

Explain that as students read their case, they should compare it to Afar, looking back at the Afar Noticings and Wonderings poster if needed. Tell them to note any similarities, differences, and other potentially relevant information that might help explain why their earthquake occurred on *Case Comparisons*, to share with their group. Give them 4 minutes to read their case and complete Step 1 of the handout.

✱ **ATTENDING TO EQUITY**

Universal Design for Learning: Not all students will *perceive* the text in the same way. Consider offering an auditory alternative. This can be done by using text-to-speech capabilities of various platforms with the Google Docs or PDF version of the text, allowing for a partner or "intervener" to read the text aloud, or by creating a narrated video (including images) of each case, among other options.

✱ **ATTENDING TO EQUITY**

Universal Design for Learning: Offering individual choice of earthquake case increases *engagement* by allowing students to weigh their own perceived level of challenge of each text and their level of personal interest in each location. Give them time to make this assessment and choose their own case within their groups to increase the degree that they feel connected to their learning.

✱ **ATTENDING TO EQUITY**

The *Earthquake Cases* are provided in multiple modalities to increase accessibility. The digital StoryMap version may be a more convenient or engaging way to access the material; its motion, however, may be overwhelming for some students. Consider using the PDF or Google Docs version of the

text for those who would benefit from reduced sensory stimulation.

6 · JIGSAW THE EARTHQUAKE CASE READINGS

10 min

MATERIALS: *Case Comparisons*, https://arcg.is/OKC4ai (optional), *Earthquake Cases*

Share patterns in small groups. Present **slide K**. Say, *Now that we've learned more about some of the earthquakes that are and are not on plate boundaries, let's see if we've noticed any similarities that might indicate patterns, or differences that might explain why earthquakes occurred in these different regions.*

Ask each student to share what they learned about their specific earthquake case, one by one within their group, spending no more than 1 minute apiece in explaining their case. Remind them to also share any similarities and differences with the Afar earthquakes. As the group members listen, they are to complete Step 2 on the *Case Comparisons*.

As the groups work, circulate and listen to their stories. Accentuate any observations about cracks in the ground, multiple earthquakes happening in the same location (aftershocks and the like), and all earthquakes being located on faults/seismic zones. After 7 minutes of sharing and recording ideas in groups, bring the class back together.

Tell students they will be able to share any patterns and similarities their group uncovered in the next class period. In the meantime, we will collect and use stories from our community to learn more about earthquakes that we, or others who we know and trust, have experienced.

7 · NAVIGATE: ASSIGN HOME LEARNING

2 min

MATERIALS: None

Introduce the home learning. Project **slide L**. Explain that because we are looking at the sudden events on Earth's surface--like volcanic eruptions and cracks--surrounding a series of earthquakes, it might be helpful to learn about the experiences that other people in our community have had with earthquakes, volcanoes, or other sudden Earth changes. ✱

Instruct students to ask trusted friends and adults about their experiences before, during, and after an earthquake, volcanic activity, or some other sudden change to Earth's surface, and ask them what they noticed. The interviewees can also share what they have heard about past earthquakes.

Tell students to record these stories in any way they see fit, or just listen. Let them know they will be invited, but not required, to share the stories in the next class period. Remind them that the event should be a sudden change to Earth's surface itself, not a weather event or a fire. ✱

✱ ATTENDING TO EQUITY

Supporting empathy and emotions: Often in science classrooms, we focus on evidence and data. When addressing a phenomenon or design solution that straddles the nature-cultural divide, like this one, supporting students in using an empathy or social and

ALTERNATE ACTIVITY	Consider creating a digital space, like a post in Google Classroom or a Flip link, where students can share these stories on day 2. If most or all students know someone with an experience to share, this is also a great opportunity to collaborate with an English language arts teacher for students to create expository texts using Common Core standards such as CCSS.ELA-LITERACY.W.9-10.2 or CCSS.ELA-LITERACY.W.9-10.3.
ADDITIONAL GUIDANCE	Students may bring in stories of erosion events, such as the creation of a sinkhole, cracking in dry soil, or a landslide. Keep the focus on sudden and unexpected changes related to the events in Afar, such as volcanic activity or earthquakes, but do not shut down other ideas or questions or mark them as irrelevant. Keep track of these events on the Scale Chart poster and allow for questions about them on the DQB; however, these will not all be addressed in this unit, particularly surface processes related to water and weather. If these questions and ideas are lingering at the end of the unit, encourage students to investigate the cause on their own. Help them see that the same tools we used in this unit to investigate stability and change across scales can be used to understand processes like the formation of the Grand Canyon (erosion over great time and great space) and a mudslide (erosion over small time and small space).

emotional lens is also important. Earthquakes can be traumatic and devastating; for some students, their lives and families may have been (or may still be) greatly affected by an earthquake. Acknowledge this without putting anyone on the spot. For more guidance around supporting the development of social and emotional learning, visit https://casel.org/ .

✱ ATTENDING TO EQUITY

Framing students' families and communities as legitimate funds of knowledge serves multiple purposes: it (1) helps students feel that they belong in the science classroom by situating their family and community knowledge as productive resources for science, (2) engages their families in conversations about what is happening in the classroom, and (3) helps them make connections between the science classroom and their everyday lives.

End of day 1

8 · NAVIGATE: SHARE EXPERIENCES OF RELATED EARTH PHENOMENA

4 min

MATERIALS: *World Map*, 3x3 sticky notes, Community Agreements poster

Share experiences. Set the stage by reminding the class that events like earthquakes and eruptions can be devastating and traumatic. Have students look back at our Community Agreements poster and choose one that will make the classroom space feel safer for people who feel comfortable sharing. Invite them to share stories from the home learning, but remind them that this is optional.

Display **slide M**. Use the first two prompts to structure sharing with the class:

- *Where did the event you learned about, or have experienced, occur?*
- *What happened before, during, and after the event?*

ADDITIONAL GUIDANCE

Social and Emotional Learning (SEL): Some students may have experienced trauma related to earthquakes or other events like those in the Afar region. Prior to teaching this lesson, please review the *Afar SEL Supports*. Be mindful of any changes in students' behavior, such as body language adjustments, intonation, and distraction. If a student exhibits any changes, consider asking them privately and quietly whether they would like to step out and see the counselor or take a moment to themselves for a break in the hallway or bathroom.

As students share, use sticky notes to add the events to the world map you prepared ahead of time (as a wall artifact or digitally; see the Materials Preparation section). On each sticky, include the location, a very short description of the event's observable effects, and the person who shared it.

Use the slide's third prompt to ask other students to compare the shared event to Afar:

- *Were there any similarities or differences between this event and the events that occurred in the Afar region?*

Record the similarities on the map, elevating any cracks or changes in land and whether any volcanic activity occurred with an earthquake. After students have shared their stories, thank them for sharing.

9 · REVISIT AFAR AND SHARE PATTERNS IN EARTHQUAKE CASE READINGS

10 min

MATERIALS: *Case Comparisons*, https://arcg.is/OKC4ai (optional), *Earthquake Cases*, Afar Noticings and Wonderings poster, dry erase marker

Revisit the Afar events. Project **slide N**. Remind students that as we learned more about our earthquake cases, we were comparing these to Afar to try to explain what was happening there, and to determine whether that could also occur at their case's location. Have them gather in their groups again and look back at the Afar Noticings and Wonderings. Direct them to discuss similarities and differences between their cases and Afar, and to complete Step 3 of the *Case Comparisons*.

Share similarities and differences. Display **slide O**. Ask students to share any interesting similarities and differences between Afar and their case sites with the class, one case at a time. As they share similarities across a couple of cases, ask whether they think these could possibly be a pattern. Have them record these ideas on their handouts if they have not already, while you do this on a whiteboard or other highly visible space in the classroom. Make sure to elevate the similarity that all the earthquakes resulted in cracks or shifts in land, as in the Afar region.

Listen for the following:

- Similarities:

✱ STRATEGIES FOR THIS INITIAL IDEAS DISCUSSION

Be explicit with students about your role in this Initial Ideas Discussion. You are not pressing for evidence; rather, you are capturing their ideas about what they think is happening at Afar. Accept all ideas in this discussion.

    - The earthquake cases and Afar had a lot of earthquakes around the time of the bigger events.
    - **All the earthquake cases seem to have cracks or shifts in land, like Afar.**
    - They are all in areas where earthquakes occur.
    - All the earthquakes, as well as Afar, occurred on fault lines.
- Differences:
    - The earthquake cases are not near volcanoes, but the Afar earthquake was near an active volcano.
    - The cracks seem way bigger in Afar than in North America.

If students do not mention the volcanic eruption at Afar, draw their attention back to the phenomena observed there, and guide them to make this observation again. Ask whether this is similar to or different from the events at the other sites, and add this to the whiteboard and *Case Comparisons*.

ADDITIONAL GUIDANCE

A rich, well-utilized visual and textual environment can be helpful for emerging multilingual learners to access content. If wall space is available, consider creating a class record on chart paper instead of the whiteboard, detailing the similarities and differences listed above. This can be utilized when students create their initial and consensus models, and in later lessons for navigation to determine what still needs to be explained about what makes the Afar earthquake different. If you do not create this class chart, have students refer to their handouts as needed.

After a minute or two, say, *It looks like we've found some similarities between Afar and our other earthquake cases, and also things that make them different. We've started thinking about how patterns in the data might give us clues about what could be causing the giant crack in Afar. Let's think more deeply about what could be causing those patterns of earthquakes and cracks.*

Share initial ideas about causes across cases. Present **slide P**. Ask students to share their initial ideas about what could be causing the patterns of earthquakes and cracks. ✱ Use the slide's prompts to foster the discussion:

- *What is cracking or shaking, and how?*
- *What is happening to the surface in an earthquake?*
- *What is causing the changes at the surface in our cases and Afar?*
- *Are the processes at Afar and all the cases the same? What evidence do we have?*

Accept all responses. The purpose of this step is to generate potential causes while also raising uncertainty for students to attempt to explain in their models.

10 · DEVELOP AN INITIAL MODEL FOR AFAR AND OTHER EARTHQUAKES

8 min

MATERIALS: *Case Comparisons*, *Initial Afar Models*

Develop an initial model individually. Say, *It sounds like we're arguing that the ground at all the cases, including Afar, might be changing in some way over time. But what is really cracking or breaking, how fast is it cracking or breaking, how much is cracking or breaking, and what is causing this?*

Present **slide Q**. Say, *Let's try to develop a model to explain what might have happened before the events at Afar, and what might happen there in the future. We think similar things might be happening in the regions of our earthquake cases, so let's also try to explain that in the model, to better understand if what's happening at Afar is happening at our cases as well.*

ADDITIONAL GUIDANCE

Before modeling, explicitly introduce an element of the Anchoring Phenomenon Routine: attempting to make sense. Say, *You may recall that at this point in a unit, we develop an initial model to explain something the class hasn't yet figured out. This is our "first draft" thinking. Remember, modeling can help us make sense of things--even what we don't know yet! For initial models, there are no right or wrong answers. The purpose is to get the ideas in our heads down on paper so we can clarify our own thinking and share our ideas. Then, we'll revisit our initial models throughout this unit as we make progress on figuring out the uncertainties we uncover today.*

Distribute the *Initial Afar Models* handout to each student. Emphasize that their models should include information about what is happening below Earth's surface; see the assessment guidance below. Reserve at least 4 minutes of this step for students to compare their models in pairs.

ASSESSMENT OPPORTUNITY

What to look for/listen for in the moment:

- Indication of movement, force, and/or energy transfer (e.g., arrows) between components of the model. (SEP: 2.3)
- Modeling changes in the shape or composition of the matter that makes up material at and/or below the surface, related to the changes at the surface. (SEP: 2.3)
- Discussion of different timescales, gradual versus sudden change, either in models or in written responses. (DCI: ESS2.B)
- A cause-and-effect relationship between something happening inside Earth and something happening at the surface. (CCC: 2.2)

What to do:

- If students' initial models lack information about Earth's interior, point or refer back to surface effects

(e.g., cracking, shaking, crumpling, tearing). Ask students what happened in their models to create those effects. Then ask how Earth could do something similar.

- Verbally prompt students to show which direction(s) the components are moving.
- Ask students to be specific about what timescales they are thinking about for the changes. When they make predictions, are they thinking of 10 years in the future, or more, or less? Why? Do all the changes happen at the same pace?

Building toward: 1.A Develop a diagrammatic model of relationships between Earth systems to explain what causes land to crack, break, and move, and to predict what will happen to the land in the Afar region in the future. (SEP: 2.3; CCC: 2.2; DCI: ESS2.B)

Compare models. Present **slide R**. Have student pairs compare their models using the prompts:

- *What do you have in your models that is similar? Add a check mark to indicate where your models are similar.*
- *What do you have in your models that is different? Add a question mark to indicate where your models diverge, where you disagree, or where you have questions.*

11 · REVISIT OUR COMMUNITY AGREEMENTS

5 min

MATERIALS: Community Agreements poster

Reflect on strategies for supporting Community Agreements. Say, *Next, we'll build on your ideas about what's happening below Earth's surface to make a class consensus model. This kind of sensemaking can be challenging. We made real progress in supporting each other and engaging in work like this when we reflected on and refined our Community Agreements at various points in our last unit. Let's do that again, so we can continue to push our growth as a learning community.*

Display **slide S**. Orient students to the Community Agreements poster, and give students 1-2 minutes to individually consider the question on the slide:

- *What strategies were productive for supporting our Community Agreements when we worked together in a Scientists Circle in our prior unit?*

Review these strategies as a class. Discuss any new strategies that students suggest. If the class decides to adopt a strategy as a Community Agreement, add it to the poster. ✱

✱ ATTENDING TO EQUITY

One of the reasons that OpenSciEd uses the term *community agreements* is to highlight that there is not a "normal" way to collaborate. Norming is a powerful tool for equity in the classroom when done collaboratively and thoughtfully. But be aware that ideas such as *safe, respectful, polite, nice,* and *kind* are culturally embedded and can mean different things in different communities. For example, one student may define kindness as not calling out a peer in public when they say something offensive;

but another student may define kindness as being honest with peers, and sharing what is on their mind and heart right away. Whose version of kindness receives priority? When these ideas are not explored, norms can be used to police or silence justifiable hurt and anger, particularly when it comes from students who identify with marginalized communities. For examples of inclusive agreements that support equitable spaces, visit https://www.theequitylab.org/blog/why-start-with-agreements .

12 · DEVELOP AN INITIAL CONSENSUS MODEL FOR AFAR

7 min

MATERIALS: *Initial Afar Models*, Initial Consensus Model for Explaining Changes in the Afar Region poster, chart paper markers

Convene in a Scientists Circle to review our goal. Have students bring their chairs and initial models into a Scientists Circle. Say, *We just developed our own initial models for what could be causing changes at Afar and compared those with our earthquake cases. We had a lot of agreement across our models, and also some divergent ideas. Before moving on, we need to come to consensus around what we know and what we want to figure out. Let's start with the case we learned about together--the Afar case.*

Facilitate a Consensus Discussion. ✱ Present **slide T**. Ask students to look at their *Initial Afar Models* and share components, mechanisms, or interactions that were similar across models. ✱ Use the prompts in the guidance box below to elicit important systems and interactions. Sketch the components, mechanisms, and interactions that students name on the Initial Consensus Model for Explaining Changes in the Afar Region poster at the front of the classroom. Put question marks on the poster to show where the class has divergent ideas about the Afar region's past and future. We will return to this model and reevaluate these initial competing ideas as we gather more evidence throughout the unit.

KEY IDEAS

Purpose of this discussion: To develop an initial consensus model that captures the ideas we agree upon, disagree upon, or are uncertain about for what is happening below Earth's surface to cause the patterns in the cracking and breaking of land, as well as volcanic activity, at the surface in East Africa.

Listen for these areas of agreement on components that the model *may* include:

- Earth's layers
- lava and/or magma

✱ STRATEGIES FOR THIS CONSENSUS DISCUSSION

Your role as facilitator in a Consensus Discussion is to press students to take stock of where the class agrees and disagrees. Tell them explicitly that you are not writing down everything they say. Say, *Remember, my role here is to put ideas into the public arena so we can debate them and clarify where we stand as a class, even if it means we agree that we have areas of disagreement. So I might say, "What do others think of that idea?" or, "With a show of hands, how many agree with that idea, and how many disagree?" I'll only write something down when we've taken stock of it as a class.*

- arrows to show movement
- changes to the shape of the land on Earth's surface
- breaking or cracking at the surface

Listen for these areas of uncertainty or disagreement:

- temporal scales of the changes (how long they take)
- changes that may be seen in the future, and how far in the future to show those changes
- spatial scales of the changes
- events at a fault line
- type(s) of changes to the shape of the land over time (e.g., some models showed the land building up, others showed it breaking apart)
- breadth and depth of the crack both above and below the surface (e.g., some models showed events deep inside Earth, others only showed them right underneath the surface)
- differences in the structure, material, state of matter, and temperature below the surface
- role of lava and/or magma in the changes observed at the surface

ADDITIONAL GUIDANCE

The initial consensus model may look something like the image below, but keep in mind that the model your class creates should represent the ideas and symbols your students come up with. If they do not come up with the idea of forces yet, do not include forces. If they already know the mantle is primarily solid rock, do not push to include magma; as we will figure out later, the role of magma is relatively small in explaining the causes of these phenomena.

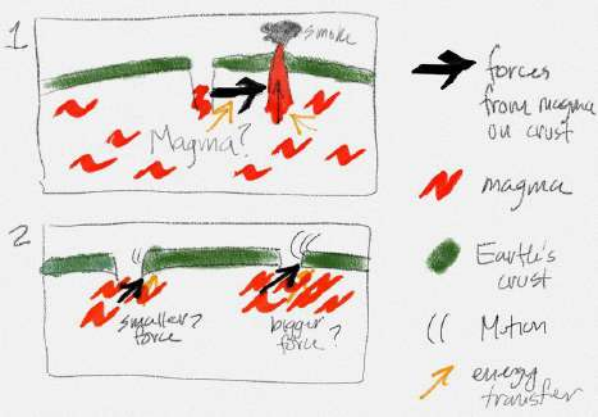
Do not push scientific vocabulary that students aren't comfortable with, but encourage them to apply familiar science phrases they have practiced in previous units to their descriptions, such as "energy transfer". For example: *I hear you saying that something would push on the rock and make it move...is it fair to say that what you just described might be a form of energy transfer?*

Listen to your students, ask clarifying questions to revoice their ideas, and make sure you understand. For example: *I heard you say _____, is that right? How should I represent that idea to capture what _____ just described? Will you come up and add that component to our consensus model?*

Encourage as many students as possible to contribute so the model represents the diverse thinking of all students. Be careful not to favorably respond to any idea over others so as not to give away what might be going on in the phenomena.

✱ ATTENDING TO EQUITY

Emerging multilingual learners: If some students have not had the chance to learn about components, mechanisms, and interactions, take a moment to introduce these terms now. Until students are comfortable with them, consider moving interchangeably between the new terms and student-friendly language (such as "parts" for "components") to allow them to develop their meanings.



13 · INTRODUCE AND USE THE SCALE CHART POSTER

6 min

MATERIALS: Scale Chart poster, Initial Consensus Model for Explaining Changes in the Afar Region poster, 3x5 sticky notes, permanent marker

Begin developing the Scale Chart poster. Ask students to remain in the Scientists Circle. Point back to the consensus model and say, *Our model is trying to explain things that are both very big and very small. It's helpful to keep track of things that happen at different scales to make sense of any connections between them.* Display the Scale Chart poster. Say, *Let's think back to what we saw happening in Afar that we documented in our model.*

Discuss the scale of the Afar phenomena. Present **slide U**. Start by asking students to consider the scale of the events at Afar, as shown in the table below.

Suggested prompt	Sample student response
What observable events happened at Afar?	A crack occurred! A volcano exploded! The ground shook!

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING PATTERNS

In high school, students should practice recognizing patterns at multiple scales. In this data set, they have the opportunity to observe several spatial scales. When patterns at multiple scales change together, it can provide evidence for correlation or even causality. In this unit, students will explain how unbalanced forces arising from properties of Earth's interior cause surface effects at both global and local scales. These surface effects occur in recognizable patterns that allow geologists to make

	The ground got lower!
What scale did those events happen at?	The crack happened over a large space. People all over the area felt the earthquake. The volcano didn't take up as much space as we think. The crack was really big, but not compared to some of the areas or continents we looked at on the earthquake and plate boundary map.

Say, *Great. Let's see whether we can put these observable events on this chart. Let's start with the crack.*

Add the Afar crack to the Scale Chart poster. Work with students to determine where the Afar crack should end up on the poster in relation to other observable features, such as the continent of Africa and the volcanic eruption. Example prompts and responses are shown in the table below.

Suggested prompt	Sample student response
Let's put the Afar crack on this chart. Does anyone remember how big it was?	It was a series of cracks that were like 37 miles long! There was the big main crack, but we could still see people standing on the sides of it.
So, let's think about where this might fall on our chart. Is it closer to something we would classify as a large space or a small space?	It seems like a large space--37 miles is a lot! It seems small, though, compared to the continent--we had to zoom in a lot on the continent to see the Afar region well.
So, it sounds like we're saying that depends on what we compare it to?	Yes! It's big compared to people, but small compared to the whole continent.

Write "Afar crack" on a 3x5 sticky note and place it somewhere on the "Large space" side of the chart. Make sure the sticky can be easily moved in later lessons as we learn more about our dynamic Earth.

inferences about the behavior of Earth's mantle.

Quickly add the other Afar events to the chart. Repeat this process, but ask students where this particular earthquake would fall on the map. Write "Afar earthquake" on another sticky and add it to the chart. Wherever students situate this earthquake is OK for now; this will be refined later. Repeat this process, asking about the volcanic eruption, and add a sticky for "Afar volcano" to the chart. ✱

ADDITIONAL GUIDANCE	It is important to note that the Scale Chart poster is a living document, to be updated throughout the unit. In this lesson, it is not critical for events to be placed in the "correct" location. This is why sticky notes are utilized, to be repositioned as our understanding develops. The image shown is only a suggestion for placement. Later, students will reconsider relative placement as processes like mantle convection and radioactive decay are added. Be sure the stickies can be easily moved from one location to another. Students will also generalize the events from being Afar-specific, such as changing "Afar earthquake" to a more general "earthquake" note as we learn more about the theory of plate tectonics.

14 · NAVIGATE: DEVELOP AN INITIAL CONSENSUS MODEL FOR OTHER CASES

5 min

MATERIALS: *Case Comparisons*, https://arcg.is/0KC4ai (optional), Initial Consensus Model for Explaining Changes in the Afar Region poster, chart paper markers, whiteboard, Scale Chart poster, 3x5 sticky notes, permanent marker

Extend the consensus model discussion to other earthquake cases. Display **slide V**. Ask students to consider how our initial consensus model does or does not reflect what we think is occurring with the other cases, or any of the events brought in from the community. Remind them that we already generated a similarities and differences list on the *Case Comparisons* and on the whiteboard chart earlier in class. Have them reflect on why these similarities--and more importantly, differences--exist.

Have students share their ideas about why the events might be different in words. Document these ideas on the right side of the consensus model poster; do not create a second visual model at this point. If students do not mention that some earthquakes occur on plate boundaries (e.g., San Francisco) but some don't, remind them, and ask how those cases might be different. If they do not bring up that their earthquake cases do not have volcanic activity, like Afar did, repeat this process.

If students wish to add a sticky note for "other earthquakes/events in North America" to the Scale Chart poster, do so now. In Lesson 2, when we learn more about earthquakes, a new 3x5 sticky that simply says "earthquakes" will be created to encapsulate the earthquakes felt around the world. Make a note to consolidate all the earthquake stickies on the Scale Chart poster into one in Lesson 2.

End of day 2

15 · NAVIGATE: BUILD THE DRIVING QUESTION BOARD

15 min

MATERIALS: 3x3 sticky notes, permanent marker (dark), science notebook, Afar Noticings and Wonderings poster, Initial Consensus Model for Explaining Changes in the Afar Region poster, Community Agreements poster, Driving Question Board

Orient students to where we have been and where we are going. Make sure the Afar Noticings and Wonderings, Initial Consensus Model for the Afar Region, and Community Agreements posters are visible at the front of the room. Display the Driving Question Board.

Say, *We've been wondering what causes land on Earth's surface to crack, break, or otherwise change over time. We looked at data for Afar and locations closer to us that seem to be breaking apart and changing. We developed initial models about what could be happening inside Earth to cause these changes at and below the surface. So, now that we've had time to think more about it, let's start building our Driving Question Board.*

Write initial questions for the DQB. Present **slide W**. Distribute 3-4 sticky notes and a permanent marker to each student. Remind students of what they have engaged in so far by referencing slide W. Say, *On these sticky notes, write at least one of your questions related to any of the data and phenomena we've considered so far. Write only one question per sticky, please, big and bold so we can all see it clearly, and don't forget to add your initials so we know who contributed it.*

Gather in a Scientists Circle around the DQB. Present **slide X**. Instruct the class to bring their sticky notes with questions to a Scientists Circle around the DQB. Explain that students will take the lead, as we did in the *Electricity Unit*. Ask for a volunteer to begin the process, and then step back. Students should use the directions on the slide for guidance. Step in when necessary to point to the relevant Community Agreements to encourage equitable participation. ✱

ADDITIONAL GUIDANCE

If this unit is the first of the year, consider spending some time establishing the process of creating a DQB. Explain that one purpose of the unit is to answer our questions about these earthquake cases, and in order to know our class mission, we must identify what we need to figure out. Go over the steps on **slide W** and emphasize that students lead the process. Remind them that if they have a question for the DQB but do not want to share it aloud, they can ask someone else to share it, or leave it for you to post at the beginning of the next class.

ASSESSMENT OPPORTUNITY

What to look for/listen for in the moment:

- Questions that arise from our work together about things that are too large, too slow, or too inaccessible to observe directly (e.g., properties and motion deep inside Earth). (SEP: 1.1; CCC: 3.2, 3.3)
- Questions that arise from our work together along a variety of timescales (e.g., short-term effects

✱ ATTENDING TO EQUITY

Universal Design for Learning: It is important to use the Community Agreements to cultivate an equitable learning community that promotes trusting and caring relationships fostering student *engagement*. The agreements should remind students to value the diversity of classroom community members, as well as equity in the sensemaking work we will do together this school year. It is critical that the agreements support safe and fair participation and interrupt cultural norms or stereotypes that could make science experiences feel uncomfortable.

versus long-term geologic change). (SEP: 1.1; CCC: 3.2, 3.3)

- Questions that arise from our work together that connect observations of the Afar region to larger-scale tectonic phenomena. (SEP: 1.1; DCI: ESS2.B)

What to do: Focus students on the crosscutting concepts of *patterns*, *cause and effect*, and *scale, proportion, and quantity* by posing the following questions:

1. *What kinds of questions do we have about changes to the Afar region and our other earthquake cases over **different scales** of time and space?*
2. *What kinds of questions do we have about parts of this system that are too large, too fast, or too slow to study directly?*
3. *What kinds of questions do we have about what is happening inside Earth to **cause** different **effects** at the surface in our earthquake cases and in Afar?*

Building toward: 1.B Ask questions about the mechanisms driving changes in Earth's crust that arise from careful observation of patterns in the Afar region, in order to seek additional information from indirect evidence because aspects of the phenomenon are too slow and too large to study directly. (SEP: 1.1; CCC: 3.2, 3.3; DCI: ESS2.B)

16 · REFLECT ON OUR USE OF COMMUNITY AGREEMENTS

3 min

MATERIALS: sticky dot (green), sticky dot (yellow), Community Agreements poster

Reflect on how the class has been doing on the Community Agreements. Display **slide Y**. Say, *In the last class, we revisited our Community Agreements. Think back to our discussions to develop our consensus model and build the DQB. Which agreements did we do well with, and which do we need to work on?* Direct students to mark the Community Agreements poster with green and yellow sticky dots as described on the slide. Below is an example of how this might look.

Note any patterns. Quickly elicit students' ideas to implement and add to the poster as needed.

ALTERNATE ACTIVITY	If you have a digital representation of the Community Agreements that the whole class can access at once (see the Materials Preparation section), have students mark the agreements virtually instead, with green and yellow squares/stickies or circles/dots.

17 · BRAINSTORM INVESTIGATION IDEAS

5 min

MATERIALS: Driving Question Board, Ideas for Investigations/Data We Need, chart paper markers

Develop ideas for future investigations. Present **slide Z**. Ask the question on the slide:

- *What kinds of investigations could we carry out, and what additional sources of data might we need, to figure out the answers to our questions?*

Capture students' ideas on the Ideas for Investigations/Data We Need poster, and save this poster for future reference.

Point out that over the course of this lesson, the class has discussed many events at different locations, but all the locations had one thing in common. Say, *Because earthquakes seem to be a common thread, and we are not sure whether all these events are related, how about we start with the event we have the most common experiences with--earthquakes.*

Navigate with a Stop and Jot. Present **slide AA**. Pose the prompts on the slide:

- *What could be causing the land to move or crack?*
- *Does land only move and crack during an earthquake, or could it happen where there is no perceptible shaking?*

Have students consider what could be happening at the land where an earthquake occurs. Ask for volunteers to share their responses with the class. Encourage students to respond to each other's ideas to draw out a variety of thoughts. Tell them that in our next lesson, we will need to explore the changes that might occur to the land.

Additional Lesson 1 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

Students read about an earthquake case and compare and contrast it with information from the Afar StoryMap text. They also compare their case to other cases to determine what they have in common, citing specific evidence from the text.

CCSS.ELA-LITERACY.SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

Students discuss earthquake cases in diverse groups and share text-based information about their cases, building on each other's ideas to find similarities between the sites and the Afar case. Students also share their initial models with partners and with the class in the larger Consensus Discussion. In addition, students share their ideas across multiple diverse groups throughout the lesson.

CCSS.ELA-LITERACY.SL.9-10.1.A Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.

Students utilize information from their earthquake case reading and the Afar StoryMap to engage in the Consensus Discussion, using evidence from texts to engage in a thoughtful exchange of ideas related to the potential cause for the earthquake and potentially related surface features in the earthquake regions.