LESSON 2: How are patterns in earthquakes similar or different in locations around the world?

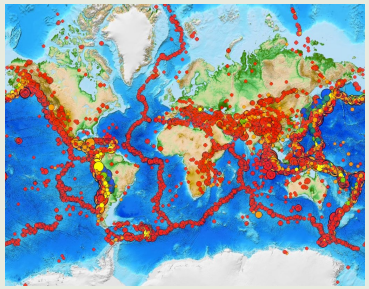
PREVIOUS LESSON

We observed videos clips and read about how Mt. Everest changed its normal motion during an earthquake. We learned that Mt. Everest is constantly moving northeast and growing taller, but moved back southwest during the earthquake. We examined earthquake data from an interactive and noticed a potential connection between the locations of earthquakes and mountain ranges. We developed an initial model explaining how mountains grow, move, and change during earthquakes. We brainstormed related phenomena and asked questions in order to generate a list of data and information we need to better understand the phenomenon.

THIS LESSON

INVESTIGATION

2 days



In this lesson, we gather more evidence of earthquake activity in different locations around the world using the Seismic Explorer tool. We look for patterns in earthquake activity in the Himalayas, the United States, and worldwide, and we figure out that earthquakes tend to form in "line" or "cluster" patterns in these places. We can see different patterns when we zoom in and out, and change the time scale for the earthquake activity. We examine other locations with earthquakes to determine whether worldwide earthquake patterns emerge, or if each location is comprised of a set of isolated events. We figure out that these locations share similarities, but also have differences. We also notice that there are interesting connections between earthquakes and local landforms. This makes us wonder why earthquakes tend to happen in places that have mountains, volcanoes, and other notable landforms.

NEXT LESSON

We will read about and analyze data to determine the potential locations of major and minor plates on Earth's surface. We will learn about how scientists study these plates and their movement. We will analyze the data for Mt. Everest and our other site locations to notice patterns in the movement of the plates.

BUILDING TOWARD NGSS

MS-ESS1-4, MS-ESS2-1, MS-ESS2-2, MS-ESS2-3

WHAT STUDENTS WILL DO

Use digital tools to examine a large data set at different spatial and temporal scales to compare global earthquake activity to local activity.

Analyze graphical displays of earthquake and topographic data in specific locations to compare local patterns to global ones, and to identify relationships between earthquake locations and topographic features.

WHAT STUDENTS WILL FIGURE OUT

- Earthquakes look like they mostly happen along lines (i.e., continent edges, the middle of the ocean, around the ocean) or in large clusters.
- In some locations, earthquakes get deeper as you move inland, but in other locations earthquakes are mostly shallow.
- When you only look at a short time period, a pattern is not as clear as when you look at data across a longer time period.
- Every location with earthquakes appears "bumpy" on the relief map, which indicates higher elevations (i.e. hills and mountains), including underwater.

Lesson 2 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review students' ideas about the Mt. Everest earthquake and then elicit noticings regarding earthquake locations based on observations from Seismic Explorer.	A	
2	8 min	**SET THE PURPOSE FOR GATHERING DATA** Revisit the DQB and Ideas for Data and Information to set the class' shared purpose for taking a closer look at earthquake data.	B-C	
3	10 min	**DEMONSTRATE SEISMIC EXPLORER** Orient students to the Seismic Explorer tool to prepare them for small group investigations. Spend a few minutes together examining the pattern of earthquakes near Mt. Everest, adjusting the spatial and time scales.	D	*Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1)
4	14 min	**GATHER EVIDENCE FROM SEISMIC EXPLORER** Students work in groups to investigate earthquake data using the Seismic Explorer tool. Help class locate their state and town using the relief map.	D	*Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), chart paper, markers
5	6 min	**FACILITATE AN INITIAL IDEAS DISCUSSION ABOUT EARTHQUAKE DATA** Facilitate an Initial Ideas Discussion focusing on students' observations from the data, and the patterns they identify when investigating specific locations.	E-F	chart paper, markers
6	2 min	**NAVIGATION** Generate a list of places that have interesting earthquake data.		computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1)
				End of day 1
7	5 min	**NAVIGATION** Review patterns in earthquakes the students feel they have evidence to support.	G	*Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), Earthquake Pattern chart (made on day 1)
8	20 min	**EARTHQUAKE LOCATION INVESTIGATIONS** Groups investigate one location with interesting earthquake activity. Have students examine different kinds of data in this location to identify (1) patterns in earthquake activity, and (2) connections to the local landforms or natural features.	H-J	*Case Locations* for assigned location, colored pencils or markers, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), Seismic Explorer Version 2 (https://tinyurl.com/SEVersion2)
9	6 min	**GALLERY WALK** Students make observations of the maps produced by two other groups to identify similarities and differences compared to the map of their location.	K	
10	10 min	**FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION** Facilitate a class discussion to solidify earthquake patterns based on the data. If time permits, have students add an entry to their two-column Progress Tracker.	L-M	chart paper, markers
11	4 min	**NAVIGATION** Have students complete an exit ticket to share their ideas about what is causing earthquakes in these patterns worldwide and in their assigned location.	N-O	index card
				End of day 2

Lesson 2 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • *Earthquake Patterns* handout • *Case Locations* for assigned location • colored pencils or markers • index card	• computer with internet access • Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1)	• computer with internet access • Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1) • chart paper • markers • Earthquake Pattern chart (made on day 1) • Seismic Explorer Version 2 (https://tinyurl.com/SEVersion2)

Materials preparation (25 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.

Load and check both versions of Seismic Explorer for this lesson:

- Seismic Explorer Version 1 (Mt. Everest pinned) at https://tinyurl.com/SEVersion1 . This version does not have case locations pinned.
- Seismic Explorer Version 2 (Earthquake locations pinned) at https://tinyurl.com/SEVersion2 . This version has case locations pinned for students.

Prior to day 1, take a photo of your DQB and Ideas for Data and Information poster to insert onto **slide B.** Choose the parts of the DQB and Ideas for Data and Information poster that relate closest to students' questions about earthquakes and/or earthquakes' connection to landforms.

Prior to day 2, determine the number of small groups you will use for the Earthquake Location Investigation. Each group will be assigned a specific location to further investigate in their small group. Make enough copies of *Case Locations* so that each student has a copy for their assigned location. For example, if you have a class of 28 students, make 4 copies of this document. This will end up producing 4 copies of each location for groups of 4.

Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

This lesson serves three purposes (1) to elicit and reinforce knowledge students have from 4th grade (ESS2.B: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth), (2) to build upon students' prior knowledge from 4th grade to establish that patterns in landforms are linked to patterns in seismic activity and connected in a global system, and (3) to emphasize that patterns in data change when you adjust for spatial and time scales. Students are working towards the middle school understanding that the development of landforms and earthquake activity are caused by the movement of plates as they collide and spread apart.

Where We Are NOT Going

Students may bring up "plates," "plate boundaries," and "plate tectonics" as they complete this investigation. Probe for what they mean by these words, but do not linger on the words in this lesson. Students will develop a shared understanding of them in Lessons 3 and 4, and add them to the word wall at that time.

In this unit, students learn about divergent and convergent plate boundaries, but the unit does not focus on transform plate boundaries. This is a notable deviation from the way plate boundaries are typically taught in middle school. The NGSS content for plate tectonics does not emphasize learning the different kinds of plate boundaries, but rather developing an understanding that plates "have moved great distances, collided, and spread apart." Therefore the focal locations are ones in which plates are colliding or spreading apart from one another. Transform boundaries are like transition zones where plates move past one another, but this movement is part of a larger system where plates are moving toward or away from one another. These boundaries tend to be more complicated to understand because the movement is not clearly defined. If you modify the materials to include transform boundaries, we recommend avoiding a focus on boundary types, and focusing instead on how movement at a new location, like the San Andreas Fault in California, represents a different kind of movement compared to what students learned about with the other locations.

LEARNING PLAN for LESSON 2

1 · NAVIGATION

5 min

MATERIALS: science notebook

Review students' ideas and noticings about earthquakes from lesson 1. Say, *A couple of classes ago we investigated earthquakes around the world using the Seismic Explorer tool, which showed us data about earthquakes. Investigating this data gave us some new ideas about the earthquake at Mt. Everest. Let's revisit some of our ideas and our noticings from Seismic Explorer.* Prompt students to locate *Relief Map of the World*, which is attached in their science notebook from Lesson 1. Once located, give students 2 minutes to review their noticings on their own.✱

Have students turn and talk about their ideas. Display **slide A**. Arrange students in pairs and provide one minute for each pair to turn and talk about the two prompts on the slide:

- What did we conclude about the earthquake at Mt. Everest: was it a random event or part of a pattern?
- What were some of our noticings about earthquakes from our quick look at Seismic Explorer?

Facilitate a sharing of their ideas. After students share with each other, bring the students back to a whole group discussion. Facilitate a brief sharing of ideas, as students will return to the Seismic Explorer tool in the next activity.

Suggested prompts	Sample student responses	Follow-up questions
What did we conclude about the earthquake at Mt. Everest: was it a random event or part of a pattern?	*There were a lot of earthquakes around the mountains so it seems like earthquakes happen a lot there.*	*How did we know it was a pattern?*
What were some of our noticings about earthquakes from our quick look at Seismic Explorer?	*There were a lot of earthquakes in some areas, but not in others.* *There were a bunch of earthquakes in the middle of the Atlantic Ocean.*	*Did we have any wonderings that we really need to answer?*
Do we think, based on our previous examination of the data, that earthquakes could happen near other mountains?	*They seemed to happen near mountains.* *They happened between oceans and continents or in the middle of the ocean.*	*If we look at the data again, what should we pay attention to?*

✱ ATTENDING TO EQUITY

This lesson gives students an opportunity to participate in both structured and open-ended explorations of earthquake data to satisfy some of their initial curiosities about where earthquakes most commonly occur. On day 1 be prepared to zoom into the United States using the Seismic Explorer tool and to zoom into your region or the area around your town or city. This will give students an opportunity to investigate earthquake activity that is closer to home compared to the activity seen in lesson 1.

2 · SET THE PURPOSE FOR GATHERING DATA

8 min

MATERIALS: science notebook

ADDITIONAL GUIDANCE	Prior to day 1, take a photo of your DQB and Ideas for Data and Information poster to insert onto **slide B.** Choose the parts of the DQB and Ideas for Data and Information poster that relate closest to students' questions about earthquakes, earthquake patterns, and/or earthquakes related to landforms. If you prefer, create one slide for DQB images and another slide for images of the Ideas for Data and Information poster.

✱ SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS

Use the DQB to establish a purpose for investigations of earthquake data. Display **slide B,** which should contain a snapshot of the DQB and questions focusing on earthquakes and/or earthquakes' connection to landforms. Ask the students who added these questions to the DQB to share what they were thinking when they added the question(s).✱ Spend about 2-3 minutes allowing students to elaborate on their thinking about these questions. Example questions from the DQB that may be related include:

- *Do earthquakes happen around mountains?*
- *Why are there so many earthquakes?*
- *Do the earthquakes follow the edges of continents (or plates)?*

Transition to looking at the data students want/need to answer their questions. Keep **slide B** displayed. Spend 1 minute reviewing students' ideas from this poster. Ask the group who generated these ideas to share their thinking. Give them about 1 minute to share.

Then say, *It sounds like we have lots of questions about earthquakes, and we want to learn more about where they happen and why they happen in certain places. Last class, we concluded that we think earthquakes happen in patterns and we noticed some areas with more or less earthquakes.*

Introduce students to the lesson question. *Say, It sounds like we have some wonderings about whether these earthquake patterns are similar or different in different places around the world? Let's see if we can figure this out.*

Display **slide C** and use the prompts to facilitate a discussion about how another look at this data could help them answer some of their questions.

- If we use the Seismic Explorer tool like we did before, what data do we want to look at?
- How will this data help us answer our questions?

Suggested prompt	Sample student response
If we use the Seismic Explorer tool like we did before, what data do we want to look at?	*We want to look closer at different parts of the world where there were a lot of earthquakes.* *We want to see which place has the most earthquakes.* *We want to see if there are earthquakes near us.* *We want to see if there are mountains near earthquakes.*
How will this data help us answer our questions?	*The data will help us know where earthquakes happen.* *We can find out if they happen often or not often.* *We can see if there are mountain ranges near earthquakes.*

The purpose of starting with students' questions from the DQB, is to make visible to students that the questions they ask will help direct their learning in the unit. When using questions from the DQB to guide investigations, give students the opportunity to elaborate on their rationale for asking the questions in the first place. If there are multiple related questions, ask students to consider how the questions are similar or different. Use this discussion to revise their questions so that they are investigable or testable. These revised questions can serve as the lesson question and be similar to the one suggested in the teacher guide.

3 · DEMONSTRATE SEISMIC EXPLORER

10 min

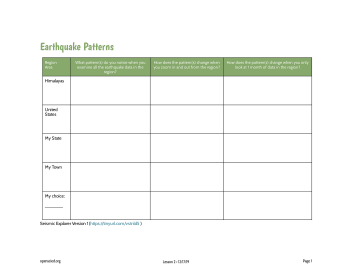
MATERIALS: science notebook, *Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1)

Demonstrate Seismic Explorer tool and discuss decisions about scale. Say, *Let's see if we can get some of this data from the Seismic Explorer tool to answer some of our questions.* Open the Seismic Explorer tool and project it for the class to view. Remind students of the relief map from Lesson 1 and what a relief map communicates. Tell students, *We're going to use Mt. Everest and the Himalayas to help us understand how to use the tool. We'll look at this together as an example before you begin your work in small groups*. Allow students to walk you through setting up an investigation of earthquake activity near Mt. Everest. Facilitate a discussion about what spatial and temporal scales to use and why it's important to decide these two things before investigating.

Suggested prompt	Sample student response
How close should we zoom in?	*Really close, but we need to see the whole mountain range, though.*
How does whether we are closer or farther affect the pattern we can see?	*If we are really close, we may only see a few earthquakes. If we are farther, there could be a lot more.*
What time period should we look at?	*Starting in April 2015, when the earthquake we read about happened.* *All of it from the very beginning.*
How does looking at more years or fewer years of data change what you can conclude about earthquakes?	*If the time is too short, then you may not have many earthquakes. If you look at more time (and more data) you can see a lot more earthquakes.*
What should our settings be to investigate what's happening at the Himalayas?	

Setup the science notebook for investigations of earthquake data. *Say, Before we make observations from the earthquake data, let's prepare our notebooks for recording our observations.* Pass out one copy of *Earthquake Patterns* handout to each student. Display **slide D**, and have students attach the handout to their notebook. Ask students to update their table of contents. Use the handout prompts, which match the prompts on the slide, to preview what information students need to record during the investigation.

- What pattern(s) do you notice when you examine all the earthquake data in the region?
- How does the pattern(s) change when you zoom in or out from the region?
- How does the pattern(s) change when you only look at 1 month of data in the region?



Earthquake Patterns

Region: Area:	What pattern(s) do you notice when you examine all the earthquake data in the region?	How does the pattern(s) change when you zoom in and out from the region?	How does the pattern(s) change when you only look at 1 month of data in the region?
Himalayas			
United States			
My State			
My Town			
My choice: _____			

Seismic Explorer Version 1.2 (https://ieqx.com/seismic/)

openstaxorg Lesson 2 - 12/12/14 Page 1

ADDITIONAL GUIDANCE	Depending on the science notebook style used in your classroom (e.g., binder, spiral notebook, or composition notebook), adjust the information on **slide D** to reflect the procedures you have in place for attaching handouts to the notebook, titling pages, and updating the table of contents.

Complete observations of the Himalayas earthquake data together. Return to the Seismic Explorer tool and start playing the data until it populates on the map. As the data populates, ask students to identify the pattern(s) that appear in the region. When all the data appears, briefly review what we are looking for when we are identifying "patterns." Listen for students to suggest ideas related to:

- Repeated earthquakes in the same place.
- A clear organization or way in which earthquakes happen across the area.
- A clear organization or way in which earthquakes happen across time.

Then give students time to write down the pattern or pattern(s) that emerged for the Himalayas on their *Earthquake Patterns* handout.

Adjust the spatial and temporal scales to record new observations. Keep the data displayed and zoom in and out of Mt. Everest. Ask students to write down what new things they notice (or no longer see) when the frame is zoomed in and zoomed out. Have students write down observations and then give them 1-2 minutes to offer their observations aloud. Now they are ready to transition to work in the tool in groups.

4 · GATHER EVIDENCE FROM SEISMIC EXPLORER

14 min

MATERIALS: science notebook, *Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), chart paper, markers

Arrange students into groups to complete investigations for other locations. Keep **slide D** displayed. Direct students to work together in their small groups to investigate the different regions or areas noted on their handout. Students should work together to adjust their parameters and to discuss what they see before recording their observations on their handouts. Circulate around to each group to assist as needed. You may need to pause groups at certain points to help the groups locate their state and their town using the relief map. They can toggle to the street map if this helps them locate places. With additional time, groups can explore other locations and add to their chart as needed.✱

As students work in their groups, prepare a chart paper titled *Earthquake Patterns* to serve as a place to record students' initial ideas. Also, load Seismic Explorer with 5 years of data (zoom out to display entire world map) to project as part of the navigation at the end of day 1.

✱ ATTENDING TO EQUITY

This investigation should be considered "sandbox" time to allow your students to work at their own pace to better understand earthquake data. The purpose is to give them time to orient themselves to the data, and to think about how time and spatial scales affect what we observe in the data. It is not necessary that all students get through each location, nor should students feel confined to only those locations. Groups that work quickly can explore other locations, while groups that move slowly should be encouraged to spend time understanding 1 or 2 locations and not feel pressured to move on quickly. The locations have been selected so that students have an opportunity to explore what is happening close to their community.

5 · FACILITATE AN INITIAL IDEAS DISCUSSION ABOUT EARTHQUAKE DATA

6 min

MATERIALS: chart paper, markers

Facilitate and Initial Ideas Discussion. Have groups of students return to their regular seats for a whole group discussion. Display **slide E.** This discussion does not require that students share everything from their observation handout during their investigations; rather, the purpose of this discussion is to generate a list of notable patterns in earthquake data that students saw in specific locations and worldwide.

KEY IDEAS

Purpose of the discussion: To identify patterns in earthquake activity in specific regions and worldwide.

What to listen for:

- In the U.S. there are a lot more earthquakes on the West coast compared to other parts of the country.
- In "my state" or "my town" earthquakes _____ .
- When you zoom into one location, the earthquakes appear to happen everywhere in the area, but cluster a little bit in some places.
- When you zoom out to the world, the earthquakes look like they mostly happen along lines or in clusters.
- Lines of earthquakes happen along the edges between the land and the ocean and in the middle of the ocean.
- When you only look at a short time period, a pattern is not as clear as when you look at the data across a longer time period.

✱ SUPPORTING STUDENTS IN ENGAGING IN USING MATHEMATICAL AND COMPUTATIONAL THINKING

Support your students in thinking about how digital tools allow us to manipulate data in ways not previously possible, and to do so with very large data sets, like earthquake activity. The earthquake data set is large because it includes thousands of events over several decades, but also because it is showing those events on a global scale Have your students consider how different ways of setting up the data (parameters) revealed or obscured important features of the earthquake patterns.

Chart ideas as each group shares a pattern. Keep **slide E** displayed and use the prompts on the slide to guide sharing. Note that each group only has about 1 minute or less to share their thinking, depending on the number of groups you have.

- Share an interesting pattern you noticed in a location.
- Share an interesting pattern you noticed when you zoomed out to the world.
- Share an interesting pattern you noticed when you shortened the time to 1 month.

As students from different groups share their observations, record students' observations of patterns and how the patterns changed with space and time on chart paper. This will be a useful reference chart for day 2.

Insert a moment to reflect on the use of this digital tool. Point out to students that this tool allowed for a lot of different explorations and manipulations of data.✱ Display **slide F**. Ask them:

- How did this tool help us to look for patterns in the data compared to looking at a paper map of earthquake data?

Listen for students to share:

- *We could change the amount of area we wanted to look at.*
- *We could change the time period for the data.*
- *We could switch between different kinds of maps.*

ASSESSMENT OPPORTUNITY	Help facilitate students shifting between spatial and time scales by prompting them to think about what looks the same and different when you zoom in or out. If students get too focused on sharing patterns in one location, move them to options 2 and 3 on **slide E**. Be prepared with example locations that typify each pattern listed in the Key Ideas box above. If students struggle to notice the patterns, be prepared to start day 2 by zooming into locations and having students describe the "shape" of the earthquake activity dots in that particular area.

6 · NAVIGATION

2 min

MATERIALS: computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1)

Project Seismic Explorer with 5 years of data, set to worldwide. Elicit from students locations that make them really curious about earthquakes. If time permits, have students come to the front and point out these locations, and share why they are curious about the places.

End of day 1

7 · NAVIGATION

5 min

MATERIALS: science notebook, *Earthquake Patterns* handout, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), Earthquake Pattern chart (made on day 1)

Have students turn and talk about interesting patterns from their investigation. Display **slide G** and arrange students in partners. Give them a minute to share an interesting pattern they noticed during the investigation.

Revise or add to the class' Earthquake Pattern chart. Bring students back together and elicit potential revisions, minor additions, or completely new additions to the chart if they feel they gathered data to support them.

ADDITIONAL GUIDANCE	The structure of this navigation time is flexible and should be responsive to where your students ended on day 1. You may need more time if your students required more time to generate their Earthquake Pattern chart. Modify this time as needed. Example modifications include: (1) if students did not clearly articulate spatial patterns, have https://tinyurl.com/SEVersion1 ready to project, and zoom in and out of different locations to articulate the patterns together. Focus the discussion on any spatial patterns that the class did not get to on day 1 (see list of patterns in the Key Ideas box on day 1), (2) if students did not clearly articulate temporal patterns, identify one interesting location and adjust the date range to show less than 1 month of data, compared to years of data in this location. Focus on articulating patterns that emerge as more data is considered that otherwise would not appear with limited data.

8 · EARTHQUAKE LOCATION INVESTIGATIONS

20 min

MATERIALS: science notebook, *Case Locations* for assigned location, colored pencils or markers, computer with internet access, Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1), Seismic Explorer Version 2 (https://tinyurl.com/SEVersion2)

Motivate wanting to look at a few locations with interesting earthquake activity. Say, *Together we've been investigating one location, Mt. Everest. We're going to keep trying to figure out what's happening at Mt. Everest working together as a class, but we're noticing a lot of other places around the world that have earthquake activity, like Mt. Everest. It may be helpful to investigate these places too, because they could be similar to or different from Mt. Everest and could help us answer many of your questions about earthquakes.*

Model for students using the Himalayas as an example. Use about 6 minutes to orient students to the task. Project the 5-year earthquake data for Mt. Everest using the Seismic Explorer Version 1 (https://tinyurl.com/SEVersion1). Zoom in fairly close to Mt. Everest. Show students how to toggle between "Map Types" to see the relief map, street map, and satellite map. With each map, pose the question:

- *What does this new map show us?*
- *What does it not show us?*
- Conclude by asking, *How can the three maps together give us a better picture of this place?*✱

Show students the *Case Locations* for the Himalayas, which is also included on **slide H**. Each case study includes one page of informational text and one page with a map of five years of earthquake data. Have students share 2-3 things they notice from the reference card. Use the prompt on the slide to set the purpose for their investigations.

- If we look at these three maps and the reference card for a location, what can we learn about earthquakes in the location?

Listen for students to share:

- *How many earthquakes happen in the place.*
- *Where the earthquakes happen.*
- *Whether the earthquakes happen in a line or cluster.*
- *Whether the earthquakes happen near cities.*
- *Whether the earthquakes happen near mountains or other landforms.*

Say, *You've generated a good list of suggestions. Let's use these as guidelines for what we need to look for as we investigate our location.*

Arrange students in groups for their investigations. Arrange students in groups of 3 or 4. Assign each group a location using the locations on **slide I** (not all locations need to be assigned). Each group needs access to one computer with internet access and each student within the group needs a copy of the *Case Locations* for their assigned location. They also need access to the tiny URL (Seismic Explorer Version 2 https://tinyurl.com/SEVersion2). Students also need access to colored pencils or markers.

✱ SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETING DATA

Support your students in thinking about how using multiple sets of data in concert with one another helps to uncover information and patterns that may be less clear when examining only one data set alone. In this case, by examining satellite imagery and street map views, alongside relief maps of specific locations, students are more likely to notice patterns in the types of topographical features (i.e. landforms) more often associated with areas of high earthquake activity.

✱ ATTENDING TO EQUITY

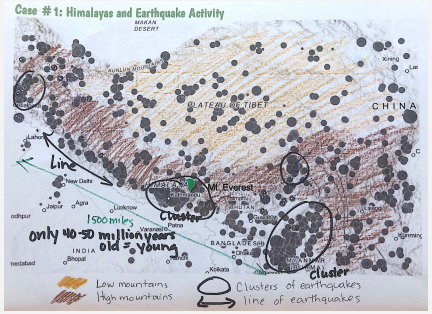
If you live in a seismically active location, you may want to add your location to these investigations. Including a local case allows for your students to consider how the science they are learning explains what is happening in and around their community. *Local Case:*_____ is a blank template provided to you to insert local data as a case option. It is recommended to include similar data and information as shown on the other location cards.

ADDITIONAL GUIDANCE

Locations can repeat across 2 groups.

- Class-level case: Himalayas (this can be assigned to a group if needed)
- Small group cases to include: Andes, Japan, Iceland, Mid-Atlantic Ridge, Baikal Rift Valley
- Optional case: Local location✱

Preview how to use the *Case Locations* reference cards to record what they find out. The students' reference documents contain one page of informational text and a full size map of five years of earthquake data. Students will read the informational text and then use markers or colored pencils to add information to their map of earthquake data (e.g., the location of interesting landforms in the area, the location of cities, and other notable features about the place). Students will attach their map to their notebook and can also attach the informational text about their location. Each group will designate one member's map to share through a Gallery Walk in the next activity.



Allow students time to work in their small groups. Display **slide J** to guide students as they read and begin their work on their maps. Cue them to pay attention to things they may want to add to their maps. Circulate around to each group as they work. Give students approximately 10-12 minutes to work on their assigned location. As groups finish, remind each group to select one group member's map to share in the Gallery Walk.

9 · GALLERY WALK

6 min

MATERIALS: science notebook

ADDITIONAL GUIDANCE

Set up students' maps around the room to spread the groups apart as they circulate. Only one group should visit another group's map.

Give students an opportunity to view other group's locations through a Gallery Walk. Display **slide K** and provide guidance to what students should pay attention to during the Gallery Walk. Explain to students that they will visit at least two other locations. For each location, students should discuss what they notice for at least 1 minute and then record similarities and differences in their science notebooks using these prompts:

- One thing you notice was similar to your group's location.
- One thing you notice was different from your group's location.

Students will only have time to view 2 other locations. Be strategic so that each group visits a location with interesting similarities and differences compared to the location they were assigned. Below is one way to assign groups so that each group views examples of a divergent and convergent boundary:

- Himalayas → Andes, Baikal Valley
- Andes → Japan, Iceland
- Japan → Himalayas, mid-Atlantic Ridge
- Baikal Valley → mid-Atlantic Ridge, Japan
- mid-Atlantic Ridge → Iceland, Andes
- Iceland → Himalayas, Baikal Valley

Add Mexico and the Aleutian Islands if you are using those locations too. Have students rotate every 3 minutes. Then ask students to return to their seats after visiting their 2nd location.

10 · FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION

10 min

MATERIALS: chart paper, markers

Facilitate a Buildings Understandings Discussion to answer the lesson question using evidence. Display **slide L**. Remind students of the question they started with on day 1 of this lesson, *How are patterns in earthquakes similar or different in locations around the world?* Throughout the discussion, emphasize the use of data to support the emerging patterns.

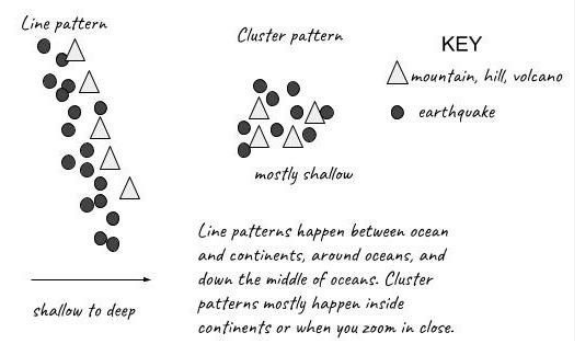
KEY IDEAS

Purpose of the discussion: to figure out that these locations share similarities and differences in earthquake patterns and to notice connections between earthquakes and local landforms (i.e., geological features).

Listen for key ideas:

- Locations with a line pattern tend to be where the ocean and land (continent or island) meet, in the middle of the ocean, or around the edges of the ocean.
- In some locations (Andes, Japan), as you move away from the ocean and further into the land, the earthquakes get deeper.
- In some locations (middle of Atlantic Ocean, Iceland, Baikal Rift Valley), the earthquakes are all the same depth and are more shallow.
- At some locations, there is a clear line of earthquakes that occur, while at other locations the earthquakes cluster into groups.
- Every location with earthquakes appears "bumpy" on the relief map, which indicates highly variable elevation (i.e. hills and mountains), including underwater.

Prompt students to decide how they want to represent an earthquake on their models, and how they may want to represent landforms, like mountains and lakes. Record these in a public location as a "key" that students will continue to use going forward. Record a group representation as students share.



Suggested prompt	Sample student response
What did we notice was similar?	*When there was a line of earthquakes, it was along a continent/land and in the middle of the ocean.* *Every location seems to have mountains or volcanoes near them.*

Suggested prompt	Sample student response
What did we notice was different?	*Some locations had mountains, other locations had a lot of volcanoes. One location was under water.* *Some locations had a pattern of earthquakes getting deeper, but other locations had mostly shallow earthquakes.*
What can we conclude from all the earthquake data we've seen?	*Earthquakes definitely happen in patterns.* *Some patterns are lines and some patterns are clusters.* *Earthquakes seem to happen most in areas with bumpy surfaces (i.e., mountains, hills, volcanoes, trenches).*
Does the evidence suggest that the earthquakes happen in areas with mountains, like Mt. Everest?	*Some of the areas had mountains like Mt. Everest, but all of them were bumpy so it seems like there could be a connection.*

ASSESSMENT OPPORTUNITY

If students struggle to identify the patterns listed above, ask students to group the locations by similarities in earthquake data. Once grouped, have students describe what makes the locations in a group similar. After establishing similarities, ask students to identify similarities or differences between the locations in a group in terms of the local landforms (i.e. mountains, hills, trenches, etc.), which may be on the ocean floor.

If time permits, have students add an entry to their two-column Progress Tracker to track their current thinking to the question, *How are patterns in earthquakes similar or different in locations around the world?*

ADDITIONAL GUIDANCE

This lesson is intended to fit within two 45-minute class period, which does not allow time for students to update their individual two-column Progress Tracker. If your class moves through the learning activities faster and/or your have a longer class period available to you, consider giving students the opportunity to complete an update to their Progress Trackers. **Slide M** is an optional slide provided to you for this purpose. Have students write and draw what they have figured out about the lesson question, *How are patterns in earthquakes similar or different in locations around the world?*

11 · NAVIGATION

4 min

MATERIALS: index card

Have students complete an exit ticket. Display **slide N** and have students complete the exit ticket to share their thinking about what is causing the earthquake patterns students have identified:

- What causes earthquakes to happen in these patterns around the world?
- What causes the earthquakes in the location you investigated?

ADDITIONAL GUIDANCE

The *Case Locations* reference cards are rich with information about each case site and students may not have read through all the information. Consider assigning reading these cards home learning to share new things they learned at the start of the next lesson. **Slide O** is provided for this purpose.