

VISUALIZATION 3: EARTHQUAKES AT DIVERGENT PLATE BOUNDARIES

as part of the series:

'Global Earthquakes: Teaching about Earthquakes with Data and 3D Visualizations'

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Activity Description

Summary of the activity:

The purpose of this activity is to introduce students to the distribution and characteristics of earthquakes associated with divergent plate boundaries. Students will learn about how the magnitude and distribution of earthquakes at divergent boundaries are related to processes that occur at these boundaries, and to the geometry and position of the two diverging plates. Because the depth of earthquakes can be difficult for students to visualize in 2D representations, this activity allows students to visualize the 3D distribution of earthquakes within Earth's surface, which is essential for understanding how different types of earthquakes occur in different tectonic settings. Locations featured in the visualization include the Mid-Atlantic Ridge, the East Pacific Rise, and the East African Rift Zone. Talking points and questions are included to use this visualization as part of an interactive lecture. In addition to playing back the visualization, instructors can also download the visualization software and data set and explore it themselves.

Intended audience:

Introductory level undergraduate students, although this visualization could be adapted for younger students with more background given.

Teaching materials:

Computer and projector to run and project visualization movie.

Conceptual Learning Goals:

- Shallow earthquakes and earthquakes with a low magnitude commonly occur at divergent plate boundaries.
- Earthquakes at divergent plate boundaries are distributed with predictable locations and depths. Earthquakes are clustered close together around the plate boundary.
- Most earthquakes at divergent plate boundaries occur at mid-ocean ridges where two pieces of oceanic crust are moving away from each other. Some earthquakes at divergent boundaries occur in the middle of continents in rift zones.

- Earthquakes at divergent plate boundaries occur as new crust is created and other crust is pushed apart. This causes the crust to crack and form faults where earthquakes occur.

Higher Order Thinking Skills Goals:

- Synthesize large data sets to recognize naturally occurring patterns
- Use patterns in data sets to make and test predictions about the distribution and characteristics of earthquakes
- Visualize data in 3D that is traditionally represented in 2D

Instructor's Notes

How to run the activity:

This visualization is designed to follow the first visualization in this series ([Visualization 1: Visualizing Global Earthquakes- Where and Why do Earthquakes Occur?](#)). However, if this visualization is used in isolation, refer to the instructor's notes accompanying the first visualization in the series for information about introducing the visualization and how the data set was compiled.

This visualization can be used in any class format, and is presented here in a way that is especially conducive for use in a lecture-based course, including very large lecture courses.

Begin the movie and use the ‘talking points’ given below to highlight key aspects of the visualization to your students. When you reach a “*Quakes Question*”, pause the visualization and ask your students the question. Instruct them to write down their ideas as you begin playing the visualization again. Once they have written down some ideas, pause the movie again, and either have them discuss their observations with a partner, or choose a few students to share with the entire class. Continue playing the visualization and pausing for questions and discussion.

Background for students:

Introduce these concepts prior to showing the visualization. Key terms are in **bold**.

- **Divergent boundaries** occur along spreading centers where plates are moving apart and new crust is created by magma pushing up from the mantle.
- [Background concepts associated with [Visualization 1: Visualizing Global Earthquakes- Where and Why do Earthquakes Occur?](#)]

Talking points:

- [0:00] This visualization focuses on divergent plate boundaries. We will look at how divergent plate boundaries are expressed in the topography and defined by the distribution of earthquakes.
- Similar to convergent plate boundaries, divergent plate boundaries are also expressed in the topography. Divergent boundaries in the ocean are called spreading centers, because they are where the crust is spreading apart.
- [0:20] The **Mid-Atlantic Ridge** is a submerged ridge that extends from the Arctic Ocean to beyond the southern tip of Africa. It occurs where the North American and Eurasian Plates are moving away from each other. The Mid-Atlantic Ridge connects to other ocean ridges that wind through the ocean basins like the seams on a baseball.

- [1:00] Another example of a divergent plate boundary is the **East-Pacific Rise**. You can see that it is not as well expressed in the topography as the Mid-Atlantic Ridge. It extends north off the western side of South America, and then up along the western margin of Mexico.
- We can also recognize divergent boundaries based on the distribution of earthquakes. We'll come back to this area to see how the plate boundary is defined by earthquakes in a minute, but first lets go back to the Mid-Atlantic Ridge.

MID-ATLANTIC RIDGE [1:40]

- Notice how the location of earthquakes corresponds with the center of the ridge.
- [1:55] Zoom in – let's take a closer look at these earthquakes. *The earth spins around to view earthquakes from multiple angles.*

'Quakes Question #1: Make some observations about the earthquakes along the Mid-Atlantic Ridge. What do you notice about how the earthquakes are distributed? How big are they? Where do they occur? *Students make a list of observations and then talk about what is happening.*

Observations:

- Earthquakes occur in a narrow line, they are all on the surface and do not extend to depth, earthquakes are all of a small magnitude.

Follow-up Discussion:

- Earthquakes at spreading centers happen as new crust is created and old rock is pushed apart. Stretching on the newly formed crust results in the crust breaking and forming faults. Slips on these faults cause earthquakes, and these earthquakes are aligned along the axis of spreading. These earthquakes are also very shallow (earthquakes at spreading ridges range from 0 to 33 km below the surface) because the crust is very thin.
- These earthquakes tend to be small because the crust is thin and there is high heat flow. Therefore, the lithosphere is weak at these boundaries so the strain cannot build up enough to cause large earthquakes.

EAST PACIFIC RISE [3:07]

- This chain of earthquakes along the Mid-Atlantic Ridge continues for a long way. We can trace this ridge and line of earthquakes around to the **East Pacific Rise**. Notice how here the topographic expression of the divergent plate boundary is less distinct, but we can still see that it is defined by earthquakes.
- [3:20] The position of these earthquakes corresponds with the plate boundary (white line).

'Quakes Question #2: Make some observations about these earthquakes. What are some characteristics of them? (as before).

- [4:30]

'Quakes Question #3: What can we say generally about the characteristics of earthquakes at divergent boundaries?

- Earthquakes are very shallow, small, and mostly only one kind of earthquakes occur.
- *Write a summary list on the board.*

EAST AFRICAN RIFT ZONE [4:57]

- Let's look at earthquakes at a different type of plate boundary. Notice here that there are clusters of earthquakes extending north-south through eastern Africa. Why are there earthquakes in this region?

'Quakes Question #4: How are the earthquakes in the East African Rift Zone similar and different from those that we saw on the Mid-Atlantic Ridge and East Pacific Rise?

- Similarities: Earthquakes are very shallow and small, and mostly only one kind of earthquake occurs. *This is because the crust is stretched very thin, making it weak so large magnitude earthquakes cannot occur.*
- Differences: The earthquakes are dispersed over a larger region; they do not define a distinct line as they do at the Mid-Atlantic Ridge and East Pacific Rise.

- [5:25] As the plate tectonic boundary map is loaded in, you can see that a plate boundary extends through East Africa and corresponds to the position of these earthquakes.

'Quakes Question #5: What type of plate boundary is this? Compare the characteristics of the earthquakes here with those that occur on continents in convergent boundaries (such as the Himalayas) and with other earthquakes at divergent boundaries.

- The earthquakes here are mostly all a small magnitude and occur very shallow in the crust. This makes them more similar to the earthquakes at the Mid-Atlantic Ridge and East Pacific Rise, than like the earthquakes at convergent boundaries.
- Earthquakes that occur on continents at convergent boundaries, like the Himalayas, are often very large, but many small magnitude earthquakes also occur. These earthquakes also extend to deeper depths than at divergent boundaries on continental crust.
- The crust is very thick at continental convergent plate boundaries, like the Himalayas. In a continental rift zone, the crust is stretched very thin, so shallow, small magnitude earthquakes occur.

- In addition to occurring in the ocean, there are also some areas where earthquakes occur at divergent plate boundaries on continents. The **East African Rift Zone** is an example of where this is occurring. The crust is very thin here and is moving apart on both sides of the plate boundary.

(NOTE: The talking points and ‘Quakes Questions’ could easily be adapted to an inquiry activity that students complete on their own as they watch the video.)

Evaluation:

‘Quakes Questions’ throughout the activity are short-answer questions that students answer while the visualization is playing to ensure that they are taking away key concepts. The final ‘Quakes Question’ requires them to synthesize ideas from this visualization and from ‘Visualization 2: Earthquakes and Convergent Plate Boundaries.’

In addition, ‘ConcepTest’ questions can also be used to assess whether students have met the goals of the activity. Because this activity provides a highly visual/spatial way of learning about earthquakes and plate boundaries the assessments should also be visual/spatial. ConcepTests are questions that focus on key concepts. Poll your students in class with these questions to ensure understanding before moving on.

ConcepTest questions can be found at <http://serc.carleton.edu/introgeo/conceptests/index.html>.

Suggested questions:

<http://serc.carleton.edu/introgeo/conceptests/examples/eqdivergentbound.html>

<http://serc.carleton.edu/introgeo/conceptests/examples/divergentbound.html>

<http://serc.carleton.edu/introgeo/conceptests/examples/divboundsketch.html>

**Note that some of these questions require students to interpret 2D representations of earthquake distribution, and some students may have difficulty mentally translating from the 3D visualization to the 2D questions causing them to answer incorrectly even if they conceptually understand.

Software download:

The visualization software used to create this visualization is freely available and can be downloaded from <http://keckcaves.org/education/>. In addition to playing back the visualizations available here, instructors can also download the visualization software and data sets and explore it themselves. Download the software and quick-start guide to begin exploring your own data sets in your classroom.