Lesson 5: How do we investigate the connection between matter in Earth's interior and surface features above?

Navigate

With a partner

1. Think back to our investigations in the last lesson.
   - What did we figure out about what causes most earthquakes?
   - How does this explanation also help us understand volcanic eruptions?

With your class

2. Earthquakes and volcanoes in East Africa did not appear to be along an established plate boundary.
   - What ideas could explain where the forces come from to cause earthquakes, volcanic eruption, and breaking in the Afar region?

Turn and talk

3. What data could we use to investigate the matter below Earth's surface to explain **where the forces might be coming from** to cause earthquakes, volcanic eruption, and breaking where there are no clear plate boundaries?

Read about Investigating Earth's Interior

With a partner

4. Read *How do scientists explore Earth's interior?* to answer some of our questions about how scientists figure out what lies beneath the surface of our planet.
   - **Use the protocol at the top of the handout to guide your reading and answer the Making Sense questions.**

Building Understanding: Digging Deep

The scale of our planet is so large that it is almost impossible to gather direct evidence about what lies beneath the surface.

With your class

5. What other systems have we learned about that cannot be studied directly, and why?

Building Understanding: Seismic Waves

Patterns in the vibrations that travel through matter from an earthquake (**seismic waves**) help scientists make inferences about Earth's structure.

With your class

6. What evidence have we seen that vibrations can travel through solid matter?

Building Understanding: P-waves

With your class

7. What do we know about P-waves from the reading that can help explain this animation?

8. If lines in the animation represent bonds between particles, where are the particles, and how are they moving?

9. What is actually traveling through the solid if it is not the particles themselves?

Building Understanding: S-waves

S-waves are back-and-forth waves that only travel through solids. P-waves can travel through any state of matter.

With your class

10. Which type of wave should reach the seismic measurement stations first?

Building Understanding: Seismic Anomalies

With your class

11. What patterns can you identify on the graph?

12. What does each of the patterns that you identified mean?

13. Where do the data appear to be different from what we would expect (an anomaly)?

14. What could we do to test whether the data matches what we expect?

15. speed = distance/time
    - Use a whiteboard or a blank sheet of paper to test 1-2 data points that appear to match our expectations.

- Then test 1-2 data points that appear anomalous. What do you notice?

Making Inferences about Earth's Structure

With your class

16. What can we infer from each part of the graph about the states of matter that make up Earth's structure?

Navigate: Earth's Layers

With a partner

17. Look at a model of how scientists believe Earth's interior is structured.
    - What do you notice? What do you wonder?
    - Which layers cause P-waves to slow down and S-waves to disappear? What is your evidence?

On your own

18. Which layers cause P-waves to slow down?
    - The speed of P-waves through liquid iron is ~9 km/s. Use this to support your claim with evidence and reasoning.

Navigate

Turn and talk

19. Look back at your Earth's Interior Model.
    - How does the energy in P-waves transfer through the **solid mantle** versus through the **liquid outer core**?
    - How does the energy in S-waves transfer through the **solid mantle** versus through the **liquid outer core**?
    - How did graphing and math support your reasoning?

Test Our Ideas

With your class

20. Observe a simulation to test our ideas.
    - Be sure to select "shadow zone" under "waves shown" before pressing play (▶).

Turn and talk

21. What do you notice about the P-waves and S-waves when they pass through Earth's
liquid core?

Simulation: Making Sense

With your class

22. Does the simulation support our model of what happens to the energy transferring in P-waves and S-waves when they pass through Earth's liquid outer core?

23. What can we infer about where the energy transfers when S-waves arrive at Earth's liquid outer core?

Earth's Mantle

With your class

24. In our model, the mantle is all the same everywhere.
    - Does this model of Earth explain why the surface of the Afar region is so active (breaking, earthquakes, volcanos), and other locations are not?
    - What else do we need to know about the mantle to figure this out?

With a partner

25. Read The Mantle and the Moho to help answer our questions about Earth's mantle
    - What might be different about the mantle rock under the Afar region?
    - How do you think the mantle rock under the Afar region might compare to the mantle rock under the region where we live?

Orient to the SubMachine Tool

With your class

26. What do you notice about the images shown by this tool?

27. Annotate the image to show what each part of the model represents.

Use the SubMachine Tool

With your class

28. What surface features did we observe in Afar that might be evidence for what is happening in the mantle?

29. How do you think the mantle beneath where we live will compare? Why do you think that?

30. Use SubMachine to observe the Afar region and compare it to our region as a class.

31. Record what the class observed in the first 2 rows of the data table provided.

Navigate and Add to Personal Glossary

With a partner

32. Record definitions for new words we encountered in this lesson in your Personal Glossary.

Return to the DQB

With your class

33. How did observing seismic waves on a local scale help us understand more about the matter in Earth's mantle?

34. What questions on the DQB might we be able to make progress on by changing from a global scale to a more local scale to investigate the mantle?

Use the SubMachine Tomography Tool

With a partner

35. Investigate at least 3 more locations.

36. Use Google Maps or Google Earth to identify relevant surface features of the locations you selected.

37. Use the provided list of coordinates to generate mantle cross section models.

38. Answer the questions in the handout to prepare for class discussion.

Building Understanding

With your class

44. What mantle patterns do you notice beneath:
volcanoes?
earthquakes?
mountains?
other surface features?

45. What do these noticings tell us about the relationship between certain surface features and the matter in the mantle beneath them?

Prepare to Communicate Your Findings

With your class

41 What have we figured out that can help explain the plate motions we observed?

42. How should we revise our *Earth's Interior Model* to reflect our new understandings about the mantle?

Revise Model of Earth's Interior

On your own

43. Add labels, symbols, drawings, and/or annotations to your model of Earth's interior to reflect our new understandings about the mantle and its matter.

Navigate

With your class

44. How does the scale of these mantle anomalies compare to the scale of the anomalies we used to figure out Earth's layers?

45. Could these anomalies change over time?

46. What DQB questions can we answer now?

Progress Tracker

On your own

47. Update your Progress Tracker.

Navigate

On your own

48. We figured out that the temperature of solid rock in Earth's mantle is **heterogeneous**, and the rock can flow like a liquid.

- What do we know about *how flowing matter of different temperatures interacts* that could explain how the mantle might change over time?