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**Title of Lesson:** After the quake: seismology in action

**Intended Grade Level(s):**

6-8th grade

**Main Objective(s):** Students will learn what causes earthquakes, how seismic waves travel, and how they can protect themselves from this natural hazard.

**Arizona State Science Standards Addressed:**

**Grade 7**

*Strand 3:* Science in Personal and Social Perspectives

## Concept 1: Changes in Environments: Describe the interactions between human populations, natural hazards, and the environment.

*Strand 6:* Earth and Space Science

* Concept 1: Structure of the Earth: Describe the composition and interactions between the structure of the Earth and its atmosphere
* Concept 2: Earth’s Processes and Systems: Understand the processes acting on the Earth and their interaction with the Earth systems.

**Common Core Standards Addressed**:

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effect

**Suggested Supplemental Teacher Resources – References/ Websites:**

<http://earthquaketrack.com/recent> shows recent earthquakes and their magnitude

<http://www.shakeout.org/schools/resources/> lists some activities and games

<http://earthquake.usgs.gov/learn/topics/> information about earthquakes from the US Geological Survey

**Lesson Plan Description:**

Students will learn about two important types of seismic waves and how to make a simple seismograph. They will then work in groups to interpret seismograms and find the epicenter of an earthquake. Further discussion will determine if surrounding cities are at risk for a tsunami. The lesson will end with a discussion on how we can protect ourselves from natural disasters.

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| **Engage** | ***Purpose***:  Introduce students to earthquakes and the waves of energy they produce.  ***Materials***:   1. [https://www.youtube.com/watch?v=JrBaiPN6AW8](https://www.youtube.com/watch?v=JrBaiPN6AW8%20)    1. This is a link to youtube videos which helps students visualize plate tectonics and faults. It also shows a seismograph and shows how a tsunami forms due to earthquakes. 2. Slinky   ***Instructional Sequence*:**   1. Start the class with the video at the beginning or at 1:07 and stop the video at 2:47. Go back and ask if students recognize the seismograph at 2:07. 2. Ask students to repeat back what causes an earthquake 3. Correct wrong answers by saying that earthquakes start when the rocks underneath of feet SNAP. This break causes waves of energy to travel away and shake the ground around the globe. 4. Demonstrate two kinds of waves that an earthquake can produce – the Primary (P) wave, and the Secondary (S) wave. This can be done with a slinky. See <https://www.youtube.com/watch?v=KZaI4MEWdc4> . A P-wave is demonstrated by stretching the slinky, compressing a few of the coils together and releasing. An S wave is demonstrated by moving the slinky like an ocean wave. This analogy is even better if there are multiple slinkys that extend from you to various students around the room. This demonstrates that seismic waves move out in all directions. **OR** one can demonstrate P and S waves by carefully (!) using the activity shown below with student volunteers <https://www.youtube.com/watch?v=gjRGIpP-Qfw> . 5. Explain that P waves move faster than S waves. This cannot be explained with a slinky, but can be explained using the activity with student volunteers. |
| **Exploration** | **Purpose**: Students will create a seismogram using a home-made seismograph  **Materials:**  Shoe boxes filled with weight (sand or other) with felt tip held on with rubber bands.  See: https://www.youtube.com/watch?v=Nz-XTyeQDhU  Stiff pads of paper  Moderately heavy object (tennis ball)  Heavy object (softball ball)  **Instructional Sequence:**   1. Tell students that they are going to use a home-made seismograph to record an earthquake. 2. In as many groups as needed, have students drop the balls at the sand filled box, while one student steadily slides the pad of paper across the attached pen. The pen should draw a mini seismograph when the balls hit. See youtube video above. 3. Ask the students to simulate as best as they can a real earthquake. Remind them that the P wave is weak but fast and the S wave is slow but strong. 4. Walk around the room to see how students are progressing 5. Hint to the students that to simulate a fast wave, the student may lightly throw the object downward, and to simulate a slow wave, the object may be dropped. Hint that a strong S wave may be simulated by the heavier object, but the weak P wave may be simulated by a light object. Remind them that both waves start at the same time, so the objects must be dropped/thrown at the same time. 6. Say an earthquake just originated at a specific point in the room. Depending on their distance to that origin, have each group drop/throw the balls from an appropriate height relative to the other groups. |
| **Explanation** | **Purpose**: Students will learn how to interpret a seismogram  **Materials:**  N/A  **Instructional Sequence:**   1. Have the groups examine their seismographs from the last exercise and have them call out their observations 2. Point out that the distance between the P and S wave is greater when the drop distance is greater. This means that the further away the earthquake started from your seismograph the greater the displacement between the P and S wave 3. Explain that scientists have correlated the time difference between the arrival of the P wave and the arrival of the S wave to a distance. This distance is how far away the earthquake started. |
| **Extend/**  **Elaboration** | **Purpose**: Students will triangulate the epicenter (origin) of the earthquake  **Materials:**  Provided map or projection of GoogleEarth on whiteboard  Measuring compasses  Attached seismograms  **Instructional Sequence:**   1. Say that an earthquake just occurred and want to figure out where it originated 2. Hand out attached seismograms to 3 groups indicated by city name – Anchorage, LA, and Honolulu 3. Have groups subtract the time that the S wave arrived from the time that the P wave arrived and have them write it on board 4. Explain that 10 is the relationship that scientists have found between the S-P time lag and the distance to where the earthquake started. This can be further explained by drawing a line graph correlating S-P time lag and distance from earthquake where 10 seconds is correlated to 100 km. 5. Have students convert their measured seconds to a distance by multiplying times 10. Write on board. Answers should be similar to table below.      1. Gather students around printed map or project a similar Google Map or Google Earth image on the whiteboard 2. Ask one student to use the calculated distance for Anchorage (885 km) to draw a circle with that radius (885 km) around Anchorage. Use the scale on map to measure that distance. Approximating is OK. 3. Explain that now we know that the earthquake is somewhere along the edge of that circle 4. Ask another student to draw LA’s calculated distance as a radius around LA 5. Explain that now we know that the earthquake could have started in one of the two places that the two circles intersect 6. Ask another student to draw Honolulu’s calculated distance as a radius around Honolulu. |
| **Evaluation** | **Purpose**: Students will evaluate what triangulation is and why it is important.  **Materials:**  **Instructional Sequence:**   1. Point out that there is a point at which all three circle touch. Ask the students what happened at that point. It is the origin of the earthquake. 2. If the three circles don’t cross at an exact point, discuss the possible errors which could be calculation errors, measurement errors, etc. 3. Ask students to describe the point of the epicenter. 4. Ask the students about what could happen since the earthquake occurred in the ocean. Remind the students about the youtube video they watched. Hopefully a student will mention the possibility of a tsunami. 5. The class can discuss which city, if any, to evacuate. Have students guess how long an evacuation would take. Note the time that this exercise took, calculate where the tsunami would be now. Use an estimate of 800 km per hour (500 mph) or 13 km (8 miles) a minute for the tsunami. The class can then discuss if there is enough time to evacuate the city. 6. The class can discuss how cities should prepare for natural disasters and how we can protect ourselves during an earthquake – stay inside, drop onto hands and knees, protect your head and neck under your desk |

**Possible Alternatives and Troubleshooting:**

This lesson plan can be split into two lessons with the first lesson ending after they make the observation about the P-S wave time lag.

Younger students could brainstorm and attempt to build buildings/houses that are earthquake resistant.

Students may question if earthquakes/tsnunamis will occur in your state/city. A quick google search will help you be prepared to answer this. <http://earthquaketrack.com/recent> shows where recent earthquakes have occurred.

**Appendix**

New vocabulary

Earthquake – shaking of the earth due to movements within the crust or volcanic activity

Tsnunami – a large sea wave often caused by an earthquake

Seismic waves – waves of energy that move through the earth

Seismograph – an instrument that measures an earthquake’s force and duration

Seismogram - a graph produced by a seismograph

Seismology – the study of earthquakes

Epicenter – the origin of an earthquake

P wave aka primary wave – the first seismic wave to arrive at a seismograph. They are compressional waves.

S wave aka secondary or shear waves – the second seismic wave to arrive at a seismograph. They shake the ground perpendicular to the way the wave is moving

S – P lag time – the time between the arrivals of the P and S wave. Seismographs further from the epicenter have a longer lag time

Triangulation – a way of determining the location of something using the location of other objects. Specifically in seismology, it is the use of various seismographs to determine the epicenter.

Analogies

Seismic waves can also be described as a drop of water falling into a full cup. The point where the drop fell is the epicenter and the concentric rings away from the epicenter are the seismic waves.











