Seismology and Citizen Seismology	Grade 12 – Geological Processes

Lesson Plan

Assessment	AFL, Activity, Exit Card
Cross-curricular	Physics

Big Ideas

- Specialized technologies have enabled us to increase our knowledge and understanding of Earth's structure and have improved the ability of scientists to monitor and predict changes in the lithosphere.

Learning Goals

- I can use the terms: seismic wave, body wave, surface wave, S-wave, P-wave, L-wave, R-wave, seismograph, epicenter.
- I can describe the characteristics of the four main types of seismic waves.
- I understand the effects of wave speed on distance versus time and time lag graphs.
- I can locate the epicenter of an earthquake given appropriate seismographic data.

Specific Expectations:

F1. analyse technological developments that have increased our knowledge of geological processes and structures, and how this knowledge assists in monitoring and managing these processes and structures;

F1.1 evaluate the accuracy and reliability of technological methods of monitoring and predicting earthquakes, tsunamis, and volcanic eruptions

F2. investigate, through the use of models and analysis of information gathered from various sources, the nature of internal and surficial Earth processes, and the ways in which these processes can be quantified;

F2.5 locate the epicentre of an earthquake, given the appropriate seismographic data (e.g., the travel-time curves to three recording stations for a single event) [

F3.2 describe the characteristics of the main types of seismic waves (i.e., P- and S-waves; R- and L-waves), and explain the different modes of travel, travel times, and types of motion associated with each.

Description:

In this lesson students will understand that earthquakes are detected using seismographs, which are instruments that record the shaking of the earth and describe the characteristics of the four main types of seismic waves. **This lesson is intended for the university level.**

Materials

Seismic Waves Notes Graphic Organizer (Student and Teacher)
Walk/Run Earthquake Location Group Materials: 2 stopwatches or other timers, Masking tape, 50 m measuring tape,
Access to "Earthquake" at http://www.sciencecourseware.com/virtualearthquake/
Walk/Run Activity Discussion Questions Answers
Exit Card (Student and Teacher)

Safety Notes

Students should pay attention to any tripping hazards during the Walk/Run Activity.

Introduction

Students start by watching the video: **Earthquakes 101**

http://video.nationalgeographic.com/video/101-videos/earthquake-101
National Geographic
© 1996-2015 National Geographic Society
© 2015-2016 National Geographic Partners,LLC.

Earthquakes usually happen along fault lines between tectonic plates. The pressure due to the Earth's hot magma builds up along these fault lines and causes the plates to shift, rub against each other, and overlap. As plates shift, pressure at these faults cause ***seismic waves*** to propagate through the earth. Other types of processes in (or on) the earth can lead to the propagation of these waves, explosions and volcanoes, and there are always smaller amplitude and lower frequency waves propagating due to human activities, atmospheric phenomena and ocean waves. There are two types of waves, ***body***, and ***surface*** waves. Of these two types, the waves are divided up into types depending on the motion of the ground and how they propagate.

Types of Waves
Next, they will learn about the different types of seismic waves in a jigsaw activity. Each group should consist of 4 students. Each group then appoints one student as the leader. Assign each student to learn one segment of seismic waves. Each group will be assigned S-waves, P-waves, L-waves or R- waves. Describe ***what type*** of wave this is, ***where*** it is found, and its ***direction of propagation***. Find an example of a video of this type of wave and prepare a labeled sketch. Next, form temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment. Bring the students back into their jigsaw groups. Ask each student to present her or his segment to the group where they will share the information about the wave and complete the note.

Take notes about these different types of waves using Seismic Waves Notes Graphic Organizer (See Link).

Here are some links about the different types of seismic waves:
http://sunshine.chpc.utah.edu/Labs/SeismicWaves/
http://www.geo.mtu.edu/UPSeis/waves.html

Earthquakes are detected using ***seismographs,*** or seismometers, which are instruments that record the shaking of the earth and create a ***seismogram*** (the squiggly graph). Inside the case of a seismograph, is a suspended mass. Once the earth starts shaking, the seismograph itself stays motionless while the case around it moves. Modern seismographs are ***electromagnets***: a permanent magnet is used for the mass and the outside case contains numerous coils of fine wire. The movements of the magnet induce small currents to flow through the wires and the measurement of these currents allows the device to record the amplitude of motion digitally. In one device, there may be multiple seismographs to record the direction of motion.

See this video for a simple explanation
How a Seismograph Works
https://www.youtube.com/watch?v=Gbd1FcuLJLQ

The distance to the ***epicentre*** of an earthquake can be determined by measuring the time lag between the S- and P- waves on the seismograph as you will see in the following activity.

Action

Next, students will learn how time lags on seismograms can be used to determine the distance to the epicentre of an earthquake.

Walk/Run Earthquake Location (See Link)
Group Materials

- 2 stop watches or other timers
- Masking tape
- 50 m measuring tape
- Access to "Earthquake" at http://www.sciencecourseware.com/virtualearthquake/

Instructions

1. Perform this activity in groups of three.
2. With the masking tape, mark 2 m intervals along a straight path for 50 m.
3. Two students will start walking together at point zero, one person will walk naturally and the other will "heel-toe" walk along the path. Both walkers should try to maintain constant speeds.
4. Each walker should keep the clock running in between markers and call out the time at each marker for the third person to record.
5. Repeat the time trial at least 3 times and find the average for your results.
6. Plot a *Distance versus Time* graph of your results. Use a suitable scale to fit both walkers' results on one graph. Draw a best-fit line for both people and calculate their *average velocity* in suitable units. (Remember that: average velocity = total distance travelled/time taken)
7. Calculate the difference between the time (t_1-t_2) for the two people to reach each distance, i.e. the "*time lag*."
8. Plot another graph of *Time Lag versus Distance* and draw a best-fit line to the data points.

Now, before proceeding complete the “Epicentre and Magnitude” section of the online module “Earthquake” at: http://www.sciencecourseware.com/virtualearthquake. Answer the online assessment and print your completion certificate. Start at “Execute Virtual Earthquake” near the bottom of the page

Discussion
For the Walk/Run Activity:

a) Which of your graphs should go through the origin?
b) How would the *Time-Lag versus Distance* graph change if the person walking was to run at a constant average velocity?
c) What would be the effect on each graph of one person changing their speed during the test?
d) What happens to the S-P gap as the distance increases?

Note: The activity presented here assumes that seismic waves travel at a constant velocity between the epicenter (the point on earth directly above the actual seismic event) of an earthquake and the seismic wave detector. In reality, the velocity of a seismic wave will change depending on the type of structure it is passing through and the epicenter can be determined more accurately if the regional velocity distribution is known. Also, if the hypocenter (the actual point of the earthquake) is very deep, it is more difficult to pinpoint.

Epicentre and Magnitude (See Link)
The location of the ***epicentre*** of an earthquake is the ground-level point at which the seismic waves start. This is at some distance from a seismograph station. If a circle is centred on the seismograph, the epicentre is on its circumference at some radius. Readings from three stations are then needed to “triangulate” the location of the epicenter where the three circles cross. The S - P time interval can then be used to determine the distance the waves have traveled from the origin to that station.

In the online Epicentre and Magnitude Activity**,** seismograms at known distances are used to measure at what time the S- or P-wave has reached the seismograph and the time lag between the two waves at that point, but in the Walk/Run activity, the *Time Lag versus Distance* graph is made directly (again, the distances are known). Once the epicentre distances are determined from the *Time Lag versus Distance* graph, circles, centered on the seismograph stations can be drawn with those radii and the point at which they cross is the epicentre.

Discussion
a) What assumptions are being made about the P and S wave velocity in the region?
b) What factor(s) would contribute to your circles not intersecting at one point?
c) What are the limitations of this way of determining earthquake magnitude?

(This activity is adapted from https://stao.ca/cms/all-documents/resources/secondary-resources/curriculum/1102-ses4u-2002-curriculum-earth-and-space-investigations/file)

Consolidation/Extension

The UC Berkley Seismological Laboratory has created a free app for Android platform phones that uses the accelerometer already located in your smart phone to detect earthquakes called MyShake. There are more than 2.6 billion smartphones worldwide that can detect earthquakes of magnitude 5 and up, up to 10 km away. They hope to create a network of information coming from participants all over the world.

The information from this network can be used to confirm that an earthquake has occurred and estimate the time, location, and magnitude of an earthquake. This information can also be used to improve algorithms to identify and predict earthquakes. In future, they hope to be able to have the capability of sending out early warnings to phone users up to minutes in advance of the seismic waves reaching their location.

Watch video for more information. (See Materials/Resources Section)
http://www.reuters.com/video/2016/03/10/myshake-app-a-personal-tsunami-warning-s?videoId=367686218

Exit Card (See Link)

There have been various Earthquake Early Warning (EEW) systems developed in quake-prone areas such as the west coast of Canada, the U.S.A., and Japan. Some such as ShakeAlarm, Quake-Catcher Network, and ShakeAlert are made up of seismometers sending signals to a computer system, which must then be attached to a network. Other networks such as the Tweet Earthquake Dispatch (TED) use Tweets including certain words, such as "earthquake", to provide seismologists with initial alerts of earthquakes felt around the globe via Twitter in less than two minutes. What would be the advantages/disadvantages of a phone app such as MyShake as an early warning system?