Unit: Dynamic Crust

May 8, 2008

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Title of lesson: **Shake, shake, shake senora, shake it all the time!!!**

Topic: How are earthquakes are measured and how to read seismograms

Grade Level: 9-10

Time Needed: An 80 minute double period lesson

Science and Math background for the teacher: For the following lesson these vocabulary words must be understood:

- **Duration** – how long something lasts
- **Earthquakes** – rapid shaking of the earth's crust
- **Epicenter** - is the location on the earth's surface that is directly above the focus of an earthquake. This is where the seismic waves first reach the surface.
- **Fault** - it is the first place where movement occurs between the plates
- **Focus**- fixed point that determines an earthquakes point of origin deep within the earth
- **Intensity** – the degree of strength, force or energy
- **Lag time –** difference in the arrival time between the p and s-waves
- **Mercalli Scale** - is used to determine how much observable damage, also called the intensity, was done by an earthquake.
- **P-waves:** compressional waves that are the fastest form of seismic waves to radiate from an earthquake and can travel through solids and liquids; also known as primary waves.
- **Richter scale** – used to determine the intensity of an earthquake by examining the altitude of a wavelength
- **Seismogram** - a piece of paper that records seismic waves Earthquakes
- **Seismograph** - a machine (instrument) that is used to detect (measure) seismic waves
- **S-waves**: Transverse earthquake waves that arrive after the P-waves and that cannot travel through a liquid such as the outer core of the Earth: also known as secondary or shear waves.
- **Travel time -** length of time it takes for the wave to get from the epicenter to the seismic station

In addition, the teacher should know:

- How to add and subtract time
  - When subtracting time you may have to "borrow" from minutes or hours.
  - It is VERY important to remember that when you are borrowing a minute to add 60 seconds to the seconds column. You can then subtract normally.
- For example:

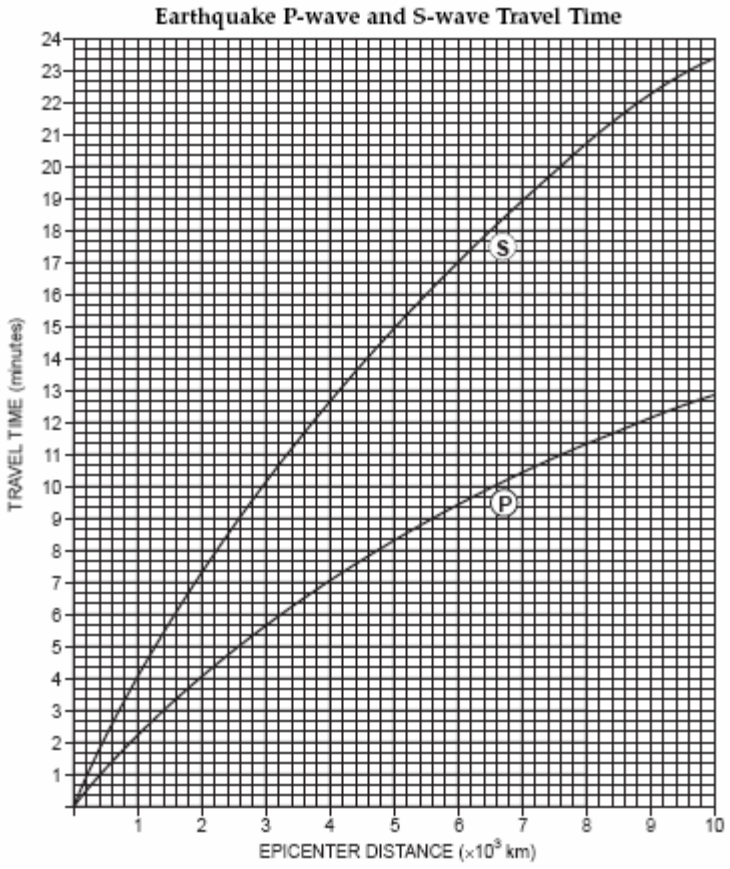
KEY
00:00:00
Hr:min:sec
60sec=1min
60min=1hr

P-wave arrival time - 11:56:30

\- P-wave travel time - 00:06:40

Time of origin - 11:49:50

- How to use Earth Science Reference Table page 11 - P and S-wave graph
  - This graph shows you the different travel times a P-wave and an S-wave travel from the epicenter (distance).
  - The x-axis represents the Distance from the Epicenter in 1000 of kilometers
  - Each tick mark on the x-axis represents 200 kilometers.
  - The y-axis represents Travel Time measured in minutes.
  - Each tick mark represents 20 seconds
  - There are two curved lines, representing the P- and S-wave



- *Teacher should refer to power point presentation for more detailed picture depth explanation.*

Instructional Objectives:

- The students will be able to:
  - Describe how earthquakes occurs
    - Rapid shaking of the earth's crust and the movement of seismic waves
  - Difference between a focus and an epicenter of an earthquake
  - Compare and contrast the different types of measuring scales
    - Richter Scale vs. Mercalli Scale
  - Differentiate between Seismogram and Seismograph
  - Interpret a seismogram
  - Know the difference between a P-wave and S-wave
  - Understand the different velocity speeds of a P and S wave
    - Understand the types of matter that each is able to travel through (solid, liquid, or gas)
    - P-waves Travel through all states of matter and S-waves only travel through solids (never liquids)
  - Calculate lag time and travel time
    - By using the Earth Science Reference Table page 11 we will be able to determine P- and S- wave travel time, lag time and the distance from the epicenter

National Science Education Standards met by this lesson:

STANDARD 4— Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

- *Key idea 2*: Many of the phenomena that we observe on Earth involve interactions among components of air, water and land.
- *Performance indicator* 22.1j Properties of Earth's internal structure (crust, mantle, inner core, and outer core) can be inferred from the analysis of the behavior of seismic waves (including velocity and refraction).
  - Analysis of seismic waves allows the determination of the location of earthquake epicenters, and the measurement of earthquake magnitude; this analysis leads to the inference that Earth's interior is composed of layers that differ in composition and states of matter.
- *Performance indicator 2.1L:* The lithosphere consists of separate plates that ride on the more fluid asthenosphere and move slowly in relationship to one another, creating convergent,

divergent, and transform plate boundaries. These motions indicate Earth is a dynamic geologic system.

- These plate boundaries are the sites of most earthquakes, volcanoes, and young mountain ranges.

STANDARD 7—Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

- *Key idea 2*: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

Materials:

Homemade seismograph – self generated

Homemade video on *how are earthquakes recorded?*-

http://qcpages.qc.cuny.edu/~gperrone100/earthquake.html

You-tube video of an earthquake - http://www.youtube.com/watch?v=m9RF5eRdG9c

PowerPoint presentation – self generated

Earth Science Reference Table's – students must have in class at all times

Worksheets to calculate travel time – self generated

Worksheets on earthquakes – self generated

Website: http://qcpages.qc.cuny.edu/~gperrone100/earthquake.html

Procedure:

Do Now: Put on you tube video of an earthquake and ask the students to figure out what they are viewing. This will allow the teacher to see what the students already know about earthquakes.

Motivation - The majority of students enjoy seeing catastrophic/violent events. By showing them the following video clip they will see how earthquake waves cause extensive damage.

http://www.youtube.com/watch?v=m9RF5eRdG9c

- Students will be asked to describe what they saw and asked to brainstorm how scientists could possibly measure the vibration of the Earth.
- Explain how earthquakes are very dangerous and have caused many casualties. An earthquake also harms society and the economy.

Students will be shown a map that shows the distributions of earthquakes that occur around the world.

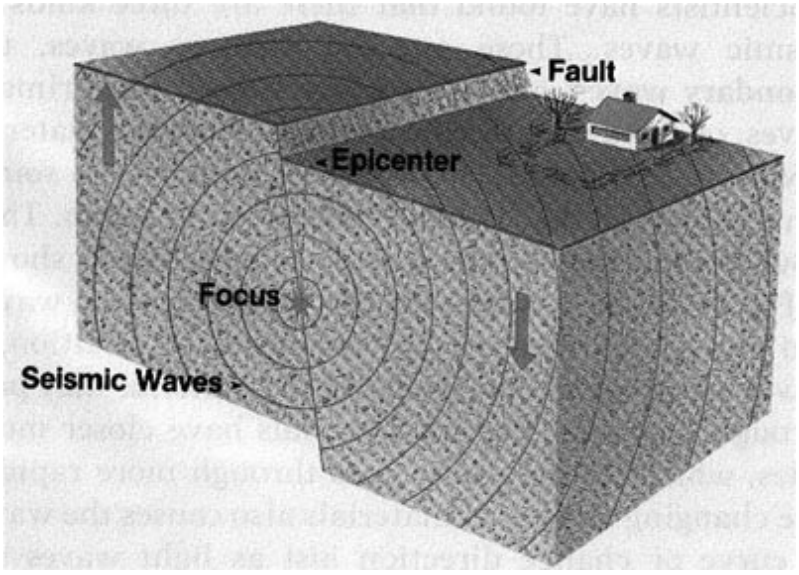
Have student watch the homemade video on how are earthquakes recorded. As they are watching the fill have them fill out the *earthquake video worksheet* that goes along with the video. They will answer the questions using the information from the video. After the video, have a class discussion on the notes as the lesson will reiterate the concepts of the video.

- Have the students give you a definition for earthquakes.

DEFINE EARTHQUAKES: an earthquake is a violent shaking of the earth's crust caused by the movement of landmasses along faults and/or subduction zones.

- ***Question:*** **Where do earthquakes occur?**
  - ***Answer*****: Plate boundaries, subduction zones, faults in the rocks**

- Most earthquakes occur when stress builds along a zone of weakness or a crack where previous motion has occurred. These areas are known as **faults (fault line).**
- **ON BOARD:** Define **Fault: it is the first place where movement occurs between the plates**
- **A fault line is where an earthquake occurs**
- When the ***stress*** on the rocks is greater than it can resist, the rocks (crust) will shift and break, *releasing enormous amount of energy*.
- The energy is given off in **seismic waves**.
- **Draw (show on Handout) diagram of an earthquake**



- ***Question:*** Point out the fault on the diagram. Ask: Looking at the arrows, what kind of plate boundary is being shown? (Look at the arrows how they are sliding past one another).
  - ***Answer*****:** This is a transform plate boundary.

- Point on the diagram, where the focus is, and explain that this is where an earthquake begins.
- **On the board:** <u>An earthquake starts at a point called the **focus** – this is where the energy of the earthquake is first emitted.</u>
- **ON BOARD** Define **<u>Focus</u>: It is a point underground that originates deep within the earth, which emits enormous amount of energy as seismic waves**
- Directly above the focus is the **Epicenter.**
- **ON BOARD** Define **<u>Epicenter</u>: is the location on the earth's surface that is directly above the focus of an earthquake. This is where the seismic waves first reach the surface.**

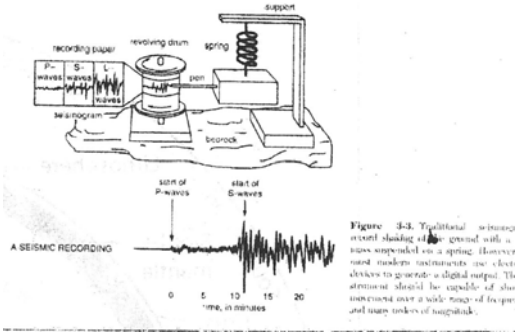
- ***Question:*** Where are the focus and the epicenter?
  - ***Answer:*** Focus is within the earth at the fault and the epicenter is right above the focus

- **<u>On the board:</u>** Directly above the focus, at earth's surface, is the epicenter (generally, the closer you are to the epicenter or focus, the greater the shaking in damage)
- **Looking at the focus, on the fault line, recall that we said that the focus emits enormous amounts of energy.**
- When rocks are together, under enormous stress, just like people, they want to be relieved from stress. There's so much build up of stress, that along this fault line, the rocks will break. There will be movement, releasing enormous amounts of energy at the focus, and this energy is given off as ***seismic waves.***

- ***Question****:* What do the circles in the diagram represent?
  - ***Answer:*** Movement of seismic waves (circles or sphere***? sphere)***

- ***Question:*** **What direction does the energy go? Does it just go up down…?**
  - ***Answer: The waves go in all directions***
- **Define seismic waves: Seismic waves the energy that an earthquake release and goes in ALL DIRECTIONS**
- ***ON THE BOARD:*** **When an earthquake occurs, the energy stored in the rocks is given off as seismic waves, also known as earthquake waves.**

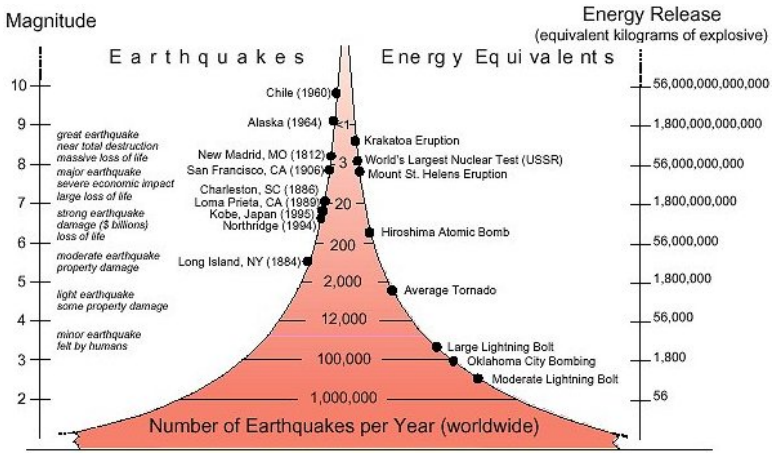
- We have all this energy being released upon the earth's crust. Scientists figured out a way to develop an instrument to measure these seismic waves called a seismograph.



- ***ON THE BOARD: A seismograph* is a machine *(*instrument) that is used to detect (measure) seismic waves**
- ***Refer to handout on what the instrument looks like.***
- **Seismic waves are recorded on a *seismogram***

- ***ON THE BOARD:* A seismogram is a piece of paper that records seismic waves**
- **Refer to handout**
    - ***By reading the seismogram, seismologists (scientists that study earthquakes) can determine the time an earthquake occurred and how far (and where), an earthquake occurred.***

- **<u>Richter scale versus Mercalli scale</u>**
- ***Question:*** How do scientists measure earthquakes? When the news reports an earthquake, they mention numbers along a scale. Do you know what scale this is referring to?
- ***Answer:*** The **Richter scale**
- ***ON BOARD:*** The Richter scale is widely used to measure the magnitude (or the amount) of energy of an earthquake. There is no limit as to how strong an earthquake may be.
- ***LOOK AT HANDOUT of the Richter scale.*** Show them on the scale that the highest magnitude is 10. However, magnitude of an earthquake is infinite.



    - ***Looking at the magnitude scale, every increase in one magnitude unit represents a tenfold increase in shaking.*** Think logarithmic scales.
    - ***A magnitude of three has ten times more shaking than a magnitude of two.*** It would also have 100 times more shaking than a magnitude of 1.

- ***Question:*** Say we have a magnitude of eight, would it be more or less energy felt at a magnitude of 7?
    - ***Answer:*** No, because eight has ten times more magnitude of shaking than a seven.

- ***Question: Looking at the center of the diagram, on Long Island, in 1884, how strong was the magnitude?***
    - ***Answer:*** ~5.5.

- ***Question: What was the largest earthquake recorded on the Richter scale?***
  - ***Answer:*** Chile, in 1960.
- ***Question***: At what magnitude?
  - ***Answer:*** ~9.5
- This is the largest earthquake that scientists have recorded but it does not mean that the strongest earthquake can have a magnitude of 10. It can be much higher than that.
- ***Question:*** At a magnitude of two, how many earthquakes were recorded?
  - ***Answer***: One million.
- ***Question***: Compare that to how many earthquakes occurred at a magnitude of eight. Does it occur more or less frequently?
  - ***Answer***: Less frequently.
- This shows that minor earthquakes occur more often on earth. It may or may not be felt by humans but the more intense earthquakes are not occurring as often. It's much better for our economy.
- ***There is another scale that helps measure earthquakes… it's a Mercalli Scale***
- ***ON BOARD*** **Mercalli Scale** is used to determine how much observable damage, also called the intensity, was done by an earthquake.
  - The scale ranges from 1-12, 1 being the least amount of damage, and 12 being the most. The numbers 1-12 are written in roman numerals.
- Look under estimated magnitude. This is showing the strength of how much energy the earthquake released in seismic waves.

Modified Mercalli Scale

Intensity	Observed Effects
I	Felt by only a few people under very special circumstances
II	Felt by only a few people at rest, especially on the upper floors of buildings
III	Felt noticeably indoors, especially on upper floors of buildings
IV	Felt indoors by many people, outdoors by a few; some awaken
V	Felt by nearly everyone; many awaken; dishes and windows break; plaster cracks
VI	Felt by everyone; many frightened and run outdoors; heavy furniture moves
VII	Everyone runs outdoors; slight to moderate damage in ordinary structures
VIII	Considerable damage in ordinary structures; chimneys and monuments fall
IX	Considerable damage in all structures; ground cracks; underground pipes break
X	Most structures destroyed; rails bend; landslides occur; water splashes over banks
XI	Few structures left standing; bridges destroyed; broad fissures in the ground; underground pipes break
XII	Damage total; waves seen on ground surfaces; objects thrown in air

- **Seismic Waves (waves that penetrate beneath the earth)**

1. **P-waves** – also called primary waves, or compressional waves
    - P-waves travel faster than all other types of seismic waves
    - They always reach the seismic stations first
    - P-waves cause particles to vibrate back and forth in the direction that a P-wave moves **(← →)**
    - P-waves can travel through solids, liquids, and gases

- ***Question***: By just looking at the names of the P and S-waves, which one do you think will travel the fastest?
    - ***Answer***: P-waves (write point on board or view on PowerPoint)

- ***Question:*** Which body wave will reach the seismic station first?
    - ***Answer:*** P-waves (write point on board or view on PowerPoint)

❖ ***Demonstrate with a slinky the motion of the P-wave (back and forth)***

- P-waves can travel through all states of matter, solid, liquid and gas. (write on board or view on PowerPoint)

2. **S-waves** – also called secondary waves, or shear waves.
    - S-waves travel slower than P-waves and reach seismic stations second.
    - S-waves cause particles to vibrate at right angles (up and down motion) to the direction that S-waves move. **(↑↓)**
    - S-waves can only travel through solids.(NEVER through liquids)

- ***Question***: Since S-waves are called Secondary waves, do they travel faster or slower than P-waves?
    - ***Answer***: They travel *slower* than P-waves and arrive second at the seismic station(write point on board or view on PowerPoint)

❖ ***Demonstrate with slinky the up and down wave like motion of an s-wave***

- ***Question:*** Why is it slower?
    - ***Answer:*** Because it takes more time for the particles to go up and come back down (think of it was an ocean wave)
- S-waves can only travel through solids. (NEVER through liquids). (write on board or view on PowerPoint)

7. PowerPoint Lesson on calculating P and S-wave travel time and lag time

With the students there is a step by step instruction through the PowerPoint lesson to show the students various ways they are able to calculate the travel time of P and S-waves and locate the epicenter distance of an earthquake. After the PowerPoint, follow up with the worksheet on *Earthquake P-wave and S-wave Travel Time Worksheet.* This will allow the students to become more familiarized with solving these types of problems.

Multicultural Connections:

By analyzing the poster titled "Earthquake Risk: A Global View", students can see that earthquakes can and have occurred throughout the world. Some areas are more prone to earthquakes because of their location along plate boundaries.

Question: How do earthquakes impact the lives of people in a community?

Answer: Students will be able to conclude that earthquakes are very dangerous and have caused many casualties by causing:

- the collapse of buildings, highway overpasses and bridges
- railroad and subway derailments
- power, water, and gas line ruptures resulting in fires

Question: How could people living in areas that are prone to earthquakes protect themselves from damage to their property? How could the community protect the people living there?

Answer:

- Reinforce foundations and highway overpasses
- Make flexible rails for trains and subways
- Protect utility lines etc.
- Look at the back of the poster titled "Earthquakes: Living with the Threat" to find out additional information.

Question: Why do earthquakes of the same magnitude cause more damage in some countries than others?

Answer: Third world countries do not have the money for earthquake technology.

Closure: For the last 5-10 minutes have students share ideas about what they thought about earthquakes and if anyone has ever experienced an earthquake? The students will summarize the concepts learned for the day on by defining the term earthquake, how earthquakes occur, and how

earthquakes are recorded. The next lesson the students will be learning how to find the location of an earthquakes on a map by analyzing 3 seismograms.

Adaptations for students with disabilities: Have hands-on activities, animations, video clips, diagrams, and/or 3D models.

Possible ways technology might be incorporated: The students may go onto the Geology Labs online Virtual Earthquake website http://nemo.sciencecourseware.org/eec/Earthquake/ that allows the student to receive a certificate at the end of completing two of the following activities: Epicenter Location and Magnitude Determination activity. The quiz consists of ten questions that attempt to assess how well the student has learned the concepts covered within the activity. If the student completes this extra activity they will receive extra credit.

Assessment: Throughout the lesson the students will be asked questions to make sure concepts are understood. For homework students will have to complete a worksheet on P and S-wave calculation of travel time. In addition, a project assignment is given to create a safety pamphlet, poster board, PowerPoint presentation, or short video that can educate people about earthquake safety.

Extension Activities: Here are some websites that students may visit to further learn about earthquakes. Many of these sites are interactive with games and activities that apply the concept of earthquakes. Many of the websites show up to date information of different seismographs around the world where students can click on a seismic station and view the recent seismogram of that area to see if any seismic activity occurred. Click on any link below and enjoy!

Latest Quakes!!!	Earthquake Word search	Earthquake Crossword Puzzle
Soil Liquification Activity	Oreo Subduction Zones	Today in Earthquake History
Earthquake Graphics	Earthquake Photos	Virtual Earthquake
Plate Tectonics Basics	Shadow Zone Animation	Become a Geophysicist
Earthquake Facts	Science of Earthquakes	Earthquakes from Past 24 Hours