Shake, Rattle and Roll

Grade Level or Special Area: 6th Grade Science
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Length of Unit: Eight lessons (approximately 50 minutes each)

I. ABSTRACT

This unit on earthquakes was designed to teach various skills by targeting the different learning styles to create a student-centered learning environment while integrating science, history, math, reading and writing, music and visual arts standards. Through a variety of techniques and skills, students will explore the cause and effect of earthquakes, use the scientific method to collect, analyze and communicate information and learn how to use graphs, data charts and manipulatives. A focus is placed on correct usage and spelling of vocabulary words to enhance literacy skills and to enable the student to apply and communicate scientific principles and theories. Students will also explore the use of technology to research and gain a better understanding of the content objectives.

II. OVERVIEW

A. Concept Objectives
   1. Understand that irregular changes occur in reaction to change in stable conditions.

B. Content from the *Core Knowledge Sequence*
   1. 6th Grade Science: Plate Tectonics (page 152)
      a. Crust movements
         i. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other.
         ii. Earthquakes cause waves (vibrations) which have:
            a) focus, the point below the surface where the quake begins
            b) epicenter, the point on the surface above the focus
         iii. Energy released is measured in the Richter scale; each unit increase on the Richter scale represents a tenfold increase in energy released.

C. Skill Objectives
   1. Explain how stress forces affect rock and cause earthquakes.
   2. Describe the types of faults, how they form and where they occur.
   3. Be able to take two column notes.
   4. Recognize and know how to spell vocabulary terms.
   5. Be able to demonstrate how stress affects rock and how the different types of faults are formed.
   6. Describe how movement along faults changes earth's surface.
   7. Explain how the energy of an earthquake travels through the Earth.
   8. List and describe the types of seismic waves.
   9. Use interactive websites to gain information.
   10. Manipulate objects on the computer using the mouse.
   11. Be able to name and identify the scales used to measure the strength of an earthquake.
   12. Explain how seismic waves are detected.
   13. Develop mastery in spelling vocabulary words using music as a stimulus.
   14. Describe and demonstrate the procedure for finding an epicenter.

15. Develop simple visual aids (drawings) to re-enforce mastery of vocabulary definitions.
16. Demonstrate how to find the epicenter of an earthquake.
17. Record data and formulate conclusions based on experimentation.
18. Use graphs to analyze data.
19. Use gross and fine motor skills to perform experiments.
20. Use the scientific method to explore a problem.

III. BACKGROUND KNOWLEDGE

A. For Teachers
1. *Earth: All Stressed Out*, by Daniel Pendick (www.pbs.org/wnet/savageearth/earthquakes)
2. *Faults*, by Maggi Glasscoe (http://scign.jpl.nasa.gov/learn/plate6.htm)
3. *Earthquakes and Society*, by Courtney Brunious and Amanda Warner, (http://www.umich.edu/~gs265/society/earthquakes.htm)

B. For Students
1. Geology – *Core Knowledge Sequence*, Grade 4, page 105
2. Plate Tectonics – *Core Knowledge Sequence*, Grade 6, page 152 (first three topics prior to earthquakes)

IV. RESOURCES

A. *Earthquakes*, by Pamela J. W. Gore, (www.dc.peachnet.edu/~pgore/geology/geo101/quakelec.htm)
B. *Earthquakes*, (www.germantown.k12.il.us/html/earthquakes.html)
C. *Science Explorer Inside Earth*, Prentice Hall (Lessons One and Five)
D. TLC Video *Great Quakes*, 1999, Family Home Entertainment (Lesson One)
E. Instrumental classical music, one slow, one medium and one fast beat (I use *Copelia Valse* by Delibes or *Annepolka* by Strauss for the slow beat, *El Amor Brujo* by Falla or *Fantasque March* by Rossini/Britten or *Mandolin Concerto in C Allegro* by Vivaldi for the medium beat and *Sabre Dance* by Katchaturin or *Minute Waltz* by Chopin for the fast beats; all these classics can be found on "The Ultimate Classical Collection – 101 Essential Classics" CD4 © 2001 Marshmellow Marketing Inc.) (Lessons Three and Five)

V. LESSONS

Lesson One: What Causes an Earthquake? Part I (50 minutes)

A. *Daily Objectives*
1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other.
3. Skill Objective(s)
   a. Explain how stress forces affect rock and cause earthquakes.
   b. Describe the types of faults, how they form and where they occur.
   c. Be able to take two column notes.

B. *Materials*
1. Text book (e.g. Prentice Hall *Inside Earth*, pages 54-57)
2. Prepared overhead transparency with two column notes (using Appendix A)

3. Earthquake video (I use TLC Video *Great Quakes*, 1999, Family Home Entertainment)
4. Student's science notebook or journal for note-taking

C. *Key Vocabulary*

1. Earthquake – shaking of the earth caused by pieces of the earth's crust that suddenly shift
2. Stress – force (push or pull) that acts on rock to change its shape or volume; adds energy to rock
3. Ahearing stress – horizontally or laterally pushes rock in two opposite directions
4. Tension stress – pulls on rock causing it to stretch and get thinner in the middle
5. Compression stress – pushes rock together causing middle to become thicker
6. Deformation – any change in shape or volume of earth's crust
7. Fault – a break in the earth's crust where movement occurs
8. Strike-slip fault – caused by shearing stress, rocks move horizontally in opposite directions, occur at transform boundaries
9. Normal fault – caused by tension forces, one block of rock moves upward (footwall) and the other moves downward (hanging wall), occurs at divergent boundaries
10. Reverse fault – caused by compression forces, hanging wall moves up and footwall moves down, occurs at convergent boundaries

D. *Procedures/Activities*

1. Warm up (WU): Have students read silently from a text (e.g. Prentice Hall *Inside Earth*, pages 54-57). Have this written on the board for them to begin doing as soon as they come into class. Allow 10 minutes and then begin with next procedure.
2. Ask students if anyone has ever been in an earthquake. Ask them to describe what it was like. Allow no more than five minutes for this.
3. Watch a short clip from a video (see Materials) that shows an earthquake happening and the effects it has. Allow two-three minutes.
4. Ask students to get out their science notebooks or journals and explain to them what the skill objectives of the lesson are while they are doing this by SAYING: "Today we are going to learn how stress forces affect rock and cause earthquakes. We will also know how to describe the types of faults, how they form and where they occur as well as practice taking two column notes."
5. **Teacher Note – See Appendix A for two column notes. Notice terms are listed on the left side of the paper and definitions or other details are located on the right side. Notes are kept brief and simple, usually four-six words per line. These notes are then used to study by folding the right side of the paper under and exposing only the side with the terms. Students then practice memorizing the definitions and flip to the opposite side to see if they got it correct. Begin teaching content and vocabulary using transparency with two column notes. Have students copy notes as you go over each term explaining how you pick what notes to take from the lecture (note taking skills). Make sure you cover the following questions: What is an earthquake and what causes it (stress)? Explain and describe the three types of stress (shearing, tension, and compression), using your hands to demonstrate the pushing, pulling or side to side movement (see vocabulary definitions). Explain and describe how each type of stress causes a certain type of fault (strike-slip, normal, reverse) to occur. Again use your hands or other objects (pieces of wood or cardboard) to represent the direction of movement of the earth's plates for each type of fault (see vocabulary definitions).

6. Circulate around the room while teaching content to check that students are properly taking notes in the two column fashion. This style of notes (taught in Step up to Writing) gives the students an easy way to study, especially vocabulary terms.
7. Homework (HW): Fold notes in half and study the 10 new vocabulary terms by starting on the side with the term and flipping to the side with the definition. Practice quizzing yourself on the definition and then flip to see if you got it right.

E. *Assessment/Evaluation*
1. Check to see if notes were properly taken and ask students to explain how they are to use them to study (see procedure five for details).

Lesson Two: What Causes an Earthquake? Part II (50 minutes)

A. *Daily Objectives*
1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other.
3. Skill Objective(s)
   a. Recognize and know how to spell vocabulary terms.
   b. Be able to demonstrate how stress affects rock and how the different types of faults are formed.
   c. Describe how movement along faults changes earth's surface.
   d. Be able to take two column notes.

B. *Materials*
1. Clay or playdough (one half can of playdough per student)
2. Student notebook or journal
3. Appendix A (two column note transparencies)
4. One piece of notebook paper per student (usually student supplied)
5. Appendix D for homework (one copy for each student)
6. Appendix E for playdough demonstration guide (one copy for the teacher)
7. Appendix I (one copy for the teacher)
8. Optional - Items used for reward (piece of candy, stickers)

C. *Key Vocabulary*
1. Friction – a force (push or pull) that opposes the motion of a surface as it moves across another surface
2. Fault-block mountain – a mountain that forms where two normal faults uplift a block of rock
3. Folds – bends in rock that form by compression stress forces
4. Plateau – large area of flat land elevated high above sea level

D. *Procedures/Activities*
1. WU – Have written on the board "In your science notebook, list as many vocabulary words as you can remember (hint – there are 10) making sure you are spelling correctly". Allow five minutes, then ask individual students to give the answers. Write the terms on the board as the students say them. Ask students who got seven or more correct to raise their hand. Give whatever you have as a reward (candy, stickers) to those students. Make sure to list any terms that were omitted by the students after you have given out rewards. Remind students the importance of studying vocabulary a few minutes each night (especially when it is homework!).

2. Put two column notes from yesterday on overhead. Cover the definitions on the right side and cover all but the top vocabulary word on the left side with a separate piece of paper.
3. Tell students: We are now going to practice spelling our science terms.
4. Start clapping your hands to a slow, steady beat that can be spelled to easily (about one clap per second). Tell students: Clap your hands to the same beat as mine. (Wait for all of them to catch the beat.) I will say the word to be spelled followed by ready, go (e.g. earthquake, ready, go). When I say go, on the next clap you will say the first letter of the word. Each time you clap, say the next letter in the word until the whole word is spelled. When you are finished keep clapping and I will say the next word, ready, go (e.g. stress, ready, go). On the next beat after I say go, you will begin spelling that word saying a letter each time you clap. Remember to keep my beat and not to speed up or slow down.
5. Begin this procedure with the first word on the transparency. When the students are finished spelling that word, move the paper down exposing the next word to be spelled. Keep doing this until you have gone through all 10 words. This should take about six-seven minutes.
6. Review the definitions of the vocabulary words by asking the students what they are. Inform them to have their science notebooks open on the page with the notes taken from yesterday and to follow along in their notes as you ask for the definitions. This helps students learn how to use their notes as well as having them correctly recall the correct answers. You will notice that by having them follow along in their notebooks with the correct answers in front of them that you will save a lot of time on the review. This should take ten minutes.
7. Ask students to get out a piece of paper. Pass out playdough. About half the amount in one can is enough for each student. Tell them to keep the playdough on the paper and not to put it straight on the desk or table. Have them form a rectangle about a half-inch thick. Make your own rectangle to use to demonstrate the correct motions. Use Appendix E for a visual of how to demonstrate using the playdough.
8. SAY: We are going to use the playdough to demonstrate the effects that stress has on rocks and also how each fault is formed. Let's do tension stress first.
9. With one hand on each end of the rectangle, pull out slowly on the playdough showing the students how the force stretches and causes the middle to become thinner. Tell them to do this and to watch the effects that tension has on the playdough. Explain that rock reacts in a similar way.
10. Tell students to remold their playdough into the rectangle. Now demonstrate compression stress by pushing the sides together showing the students that it causes the playdough to fold and get thicker in the middle. Have students do the same with their playdough.
11. Re-mold playdough. Ask students to show you how they would demonstrate shearing stress. Look around the room at how they are doing it and then hold your playdough up and demonstrate the correct way by pulling one side towards you while pushing the other side away from you. In other words, move each side in opposite directions. Observe what happens to the playdough. Now move the playdough in the opposite direction that you just did and observe what it does to the playdough.
12. Re-mold the playdough. Ask them to think about how they would demonstrate a strike-slip fault. Watch any ideas them may have and then demonstrate by moving the playdough in opposite directions like you did for shearing stress but

keep doing it back and forth until the playdough cracks. This represents the fault. Now have students do it.

13. Re-mold the playdough. Demonstrate a normal fault by gently pulling on each end of the playdough and pulling slightly downward on the right hand forming a dip (or cliff) in the clay. Have students do this.
14. Re-mold playdough. Ask students to demonstrate a reverse fault and check around the room to see how they are doing it. Then demonstrate the correct way by gently pushing in on the ends of the playdough and pushing upward with the right hand. This should form another cliff but going in the opposite direction than the normal fault.
15. Collect playdough and put away. This should take 10-12 minutes.
16. Have students open notebooks to begin taking notes. Make sure they begin exactly where they left off yesterday. Many students tend to randomly open their notebooks and begin writing anywhere. This becomes very detrimental to their organizational skills and studies. Get out the next set of transparencies beginning with the word friction.
17. Begin teaching what friction is (see vocabulary definitions). After your explanation, expose the term and definition on the transparency and have students copy the notes.
18. Explain that a small amount of friction between rocks along a fault can cause rock to crumble. Moderate amounts of friction can cause the sides of the fault to jam together. When they jerk free small earthquakes happen. Where friction is high, the rocks lock together and don't move. Stress continues to build up (transferring energy into the rock) until the rocks break free from each other causing a large earthquake.
19. Explain how fault-block mountains are formed. Have students copy notes on fault-block mountains. Then discuss how folds are formed. Have students copy notes on folds. Tell students that mountains are also formed by the folding of rocks due to compression forces. Explain how a plateau is formed and have students copy notes on plateaus. See vocabulary definitions for help.
20. HW – Worksheet (Appendix D) and study for a quiz on the 14 vocabulary words to be given in Lesson Four.

E. *Assessment/Evaluation*

1. Class discussion, demonstration and participation
2. Questions on Appendix D are answered as homework and graded using Appendix I.

Lesson Three: What Are the Effects of an Earthquake? Part I (50 minutes)

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions
2. Lesson Content
   a. Earthquakes cause waves (vibrations) which have:
      i. focus, the point below the surface where the quake begins
      ii. epicenter, the point below the surface above the focus
3. Skill Objective(s)
   a. Explain how the energy of an earthquake travels through the earth.
   b. List and describe the types of seismic waves.
   c. Recognize and know how to spell vocabulary terms by keeping a beat to music.

d. Be able to take two column notes.

B. *Materials*
1. Student science notebook
2. Appendix A (two column note transparencies)
3. Instrumental classical music, one slow, one medium and one fast beat (I use *Copelia Valse* by Delibes or *Annepolka* by Strauss for the slow beat, *El Amor Brujo* by Falla or *Fantasque March* by Rossini/Britten or *Mandolin Concerto in C Allegro* by Vivaldi for the medium beat and *Sabre Dance* by Katchaturin or *Minute Waltz* by Chopin for the fast beats; all these classics can be found on "The Ultimate Classical Collection – 101 Essential Classics" CD4 © 2001 Marshmellow Marketing Inc.)
4. Appendix B for homework (one copy for each student)
5. Appendix F for drawings (one copy for the teacher)
6. Appendix G (one copy for the teacher)

C. *Key Vocabulary*
1. Focus – the point beneath the Earth's surface where rock that is under stress breaks and causes an earthquake
2. Epicenter – point on the surface directly above the focus
3. Seismic waves – vibrations that travel through the Earth carrying energy released during an earthquake
4. Primary waves (P waves) – the first waves to arrive at the seismic station and are waves that compress and expand (push and pull)
5. Secondary waves (S waves) – come after P waves and vibrate side to side
6. Surface waves (L waves) – slowest waves occurring on the surface of the Earth

D. *Procedures/Activities*
1. WU – Write on board "Read and study your notes on earthquakes". Allow five-seven minutes.
2. Practice spelling vocabulary to music. Start with a slow song (see Materials list) and begin clapping to find a slow steady beat that matches the music. Have students begin clapping with you. Once you all have the beat begin spelling (follow procedures for this in Lesson Two).
3. Once you get through all 14 words change the music to a medium beat and repeat the procedure. After spelling all 14 words change the music to a fast beat and repeat the procedure. You will have spelled each word three times when you finish with this exercise. Students usually love this! Allow 10 minutes.
4. Do a quick review from the first two lessons by asking question from Appendix A. Allow five-seven minutes.
5. If you didn't get through all of Lesson Two now is the time to finish it up.
6. Have students open their science notebooks making sure they begin exactly where they left off yesterday.
7. Explain what the focus and epicenter of an earthquake are (see vocabulary definitions). Make drawing on board for visuals using Appendix F. Show the notes for these two terms using the transparency made from Appendix A. Allow students to copy the notes.
8. Teach seismic waves, P waves, S waves and L waves (see vocabulary definitions and Appendix A). Make drawings on board using Appendix F.
9. HW – Worksheet (Appendix B) and study the first 14 vocabulary terms (earthquake through plateau) for a quiz tomorrow.

E. *Assessment/Evaluation*
1. Class discussion and participation.
2. Check student's notes for proficiency.

3. Questions from Appendix B will be collected and graded. Use Appendix G for key.

Lesson Four: What Are the Effects of an Earthquake? Part II (50 minutes)

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Earthquakes cause waves (vibrations) which have:
      i. focus, the point below the surface where the quake begins
      ii. epicenter, the point below the surface above the focus
3. Skill Objective(s)
   a. Use interactive websites to gain information.
   b. Manipulate objects on the computer using the mouse.
   c. Be able to demonstrate how stress affects rock and how the different types of faults are formed.
   d. Describe how movement along faults changes Earth's surface.

B. *Materials*

1. Quiz from Appendix C (one copy for each student)
2. Appendix H (one copy for the teacher)
3. Computers with Internet access

C. *Key Vocabulary*

None

D. *Procedures/Activities*

1. WU – Write on the board "Five minute to study for quiz". Allow five minutes.
2. Hand out vocabulary quiz (Appendix C). Allow 15 minutes. Collect.
3. Take students to computer lab. If there aren't enough computers for each student, divide them into groups and tell them to take turns. Make sure they understand that they are only allowed to access the specified websites and to move through the exercise promptly so the next person can have a turn.
4. List the following websites on the board:
   http://scign.jpl.nasa.gov/learn/plate6.htm
   http://www.pbs.org/wnet/savageearth/eartquakes
5. Tell students to access the first website and read the paragraph on faults. Then they can press the buttons to view the movement of the faults.
6. Tell students to access the second website and go right to the animations for the strike-slip and dip-slip faults which they are to do.
7. Then tell them to read the paragraph beginning "Seismologists have developed…" When they come to the animations they are to start those and watch. Then they are to finish reading the paragraph. Stop reading where the video begins and a new paragraph starts.
8. When all students have finished, orally ask them for their input of the effectiveness of the exercise. "Did this help you understand what we are learning any better? How or why was it helpful?"

E. *Assessment/Evaluation*

1. Quiz on vocabulary words (Appendix C). Use Appendix H for key.
2. Class participation and discussion.

Lesson Five: How Are the Effects of an Earthquake Measured? Part I (50 minutes)

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Energy released is measured in the Richter scale; each unit increase on the Richter scale represents a tenfold increase in energy released.
3. Skill Objective(s)
   a. Be able to name and identify the scales used to measure the strength of an earthquake.
   b. Explain how seismic waves are detected.
   c. Describe the procedure for finding an epicenter.
   d. Develop mastery in spelling vocabulary words using music as a stimulus.
   e. Be able to take two column notes.
   f. Develop simple visual aids (drawings) to re-enforce mastery of vocabulary definitions.

B. *Materials*

1. Student science notebook
2. Appendix A (two column note transparencies)
3. Instrumental classical music (described in Lesson Three)
4. Appendix L for 'See it, Say it, Got it' drawings (one copy for the teacher)
5. Text book (e.g. Prentice Hall *Inside Earth* pages 66-69)
6. Appendix M for study guide (one copy for each student)

C. *Key Vocabulary*

1. Seismograph – an instrument that records the ground movements caused by seismic waves
2. Magnitude – a measurement of earthquake strength based on seismic waves and movement along faults
3. Mercalli scale – rates earthquakes according to their intensity or affects on a scale of I - XII
4. Richter scale – rates the size of the seismic waves on a scale of 1 – 10
5. Moment Magnitude scale – rates the total energy released by an earthquake

D. *Procedures/Activities*

1. WU – Have students read silently from a text (e.g. Prentice Hall *Inside Earth* pages 66-69). Allow 10 minutes.
2. Review spelling vocabulary to music by following procedures listed in Lesson Three. Allow six-seven minutes.
3. SAY TO STUDENTS: We are now going to learn a new technique called 'See it, Say it, Got it' to help us study and become experts on our vocabulary words. What we are going to do is to make very simple and quick drawings for our words that will help us to remember what their definitions are. (Note: not all words will be included in this activity. Students can make up their own for the remaining words).
4. Have students open their science notebooks to the first page of notes for this unit beginning with the word earthquake.
5. SAY: I am going to do a 15 second drawing that will visually describe the word earthquake. I then want you to copy that drawing down next to the word *earthquake* in your notes.
6. Make your drawing of the earthquake using Appendix L for examples. Give students no more than one minute to copy this down in their notes.

7. SAY: What we do now is to *SEE* the drawing by taking a minute to look at it (teacher will point to drawing with finger). Then we will SAY the word and its definition by using the drawing to help remind us of what it means. When we are finished saying the definition we will gently slap the picture with our hand and firmly say GOT IT. This will tell our brains that we know this!
8. Now perform this procedure. Tell students to look at the picture for about three seconds after saying 'SEE IT". Then say 'SAY IT' and you will repeat the definition of the word out loud having the students say it with you. Use Appendix A or the list from the key vocabulary from each lesson. (e.g. earthquake – an earthquake is the shaking of the Earth caused by pieces of the Earth's crust that suddenly shift). Now slap the picture with your hand and say 'GOT IT'.
9. Repeat this procedure again with the same word before moving on.
10. Repeat this same procedure for all nine words on Appendix L.
11. Tell students to use this method each night to help them study for the test. Have them do their own drawings for the rest of the vocabulary words for homework.
12. Tell students to open their notebooks to the last place they took notes and to begin taking notes there. Check to see they do this correctly.
13. Use Appendix A beginning with seismographs for two column notes.
14. Quickly review the three types of seismic waves from lesson three.
15. Teach what seismographs and magnitude is. Then discuss the Mercalli, Richter and Moment Magnitude scales. Have students copy down notes from the overhead transparency (Appendix A) as you go over each new term.
16. Then explain the procedure to locate the epicenter of an earthquake. Have students copy notes. Review the procedure immediately by asking students to repeat the steps back to you orally.
17. Let students know they will be doing a lab tomorrow as a hands-on exercise for locating the epicenter so they will need to be very familiar with the steps.
18. HW – Finish making drawings for the rest of your vocabulary words in your science notebook (there are 11 more words) and study the procedure for finding the epicenter of an earthquake.
19. Hand out study guide (Appendix M) and tell students to use this to study for test.

E. *Assessment/Evaluation*
1. Class participation and discussion.
2. Drawings for vocabulary will be checked for completion.

Lesson Six: How Are the Effects of an Earthquake Measured? Part II (50 minutes)

A. *Daily Objectives*
1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Energy released is measured in the Richter scale; each unit increase on the Richter scale represents a tenfold increase in energy released.
3. Skill Objective(s)
   a. Demonstrate how to find the epicenter of an earthquake.
   b. Record data and formulate conclusions based on experimentation.
   c. Use graphs to analyze data.
   d. Use gross and fine motor skills to perform experiments.
   e. Use the scientific method to explore a problem.

B. *Materials*
   1. Lab from Appendix J (one copy for each student)
   2. Appendix K (one copy for the teacher)
   3. Sharpened pencil for each student
   4. Drawing compasses, one for each student

C. *Key Vocabulary*
   None

D. *Procedures/Activities*
   1. WU – Have students pick up a lab and **carefully** read through it.
   2. Have students get out their drawing compasses and pencils.
   3. Read through the procedures on the lab out loud explaining each step.
   4. Show students the data table, graph and map on their lab so they are familiar with each one.
   5. Tell them once they have completed the procedures for finding the epicenter they must answer the questions in the analyze and conclude section.
   6. Let students begin working on the lab. Make sure to continuously move through out the classroom checking to see if students are performing the tasks correctly and answer any questions they may have about procedures.
   7. Have students turn in the lab by the end of the period.
   8. With the time remaining discuss the correct answers with the students so they have immediate feedback.

E. *Assessment/Evaluation*
   1. Lab will be collected and graded (see Appendix K for key)

Lesson Seven: Earthquakes: Causes and Effects Review (50 minutes)

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Understand that irregular changes occur in reaction to change in stable conditions.
   2. Lesson Content
      a. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other.
      b. Earthquakes cause waves (vibrations) which have:
         i. a focus, the point below the surface where the quake begins
         ii. epicenter, the point on the surface above the focus.
      c. Energy released is measured in the Richter scale; each unit increase on the Richter scale represents a tenfold increase in energy released.
   3. Skill Objective(s)
      a. Explain how stress forces affect rock and cause earthquakes.
      b. Describe the types of faults, how they form and where they occur.
      c. Describe how movement along faults changes earth's surface.
      d. Explain how the energy of an earthquake travels through the Earth.
      e. List and describe the types of seismic waves.
      f. Be able to name and identify the scales used to measure the strength of an earthquake.
      g. Explain how seismic waves are detected.
      h. Describe the procedure for finding an epicenter.
      i. Be able to correctly spell all vocabulary words.
      j. Be able to analyze and draw conclusions from a graph.

B. *Materials*
   1. Student science notebook

2. Appendix N (puzzle worksheet) (one copy for each student)
3. Appendix O (one copy for the teacher)
4. Appendix M (one copy for each student)
5. Appendix P (one copy for the teacher)

C. *Key Vocabulary*

Review of all previously stated vocabulary

D. *Procedures/Activities*

1. WU – Have students pick up worksheet (Appendix N) and begin working on it. Allow 20 minutes for them to complete this and collect to be graded.
2. Ask students to get out their study guides.
3. Divide class into groups. There are nine questions on the study guide so divide the groups so that the questions can be divided equally (question nine on the study guide will not be assigned in class).
4. Assign one, two or three questions to each group (depending on number of groups).
5. Students will get together in their groups to discuss the correct answers to their assigned questions. Allow about 10 – 15 minutes.
6. Have each group or a spokesperson from each group to get up in front of the class and discuss the answer to the study guide questions.
7. The teacher should use Appendix P as a key.
8. HW – Study for final test tomorrow.

E. *Assessment/Evaluation*

1. Class discussion and participation.
2. Appendix N will be collected and graded.

Lesson Eight: Earthquakes Assessment (30 – 40 minutes)

A. *Daily Objectives*

1. Concept Objective(s)
   a. Understand that irregular changes occur in reaction to change in stable conditions.
2. Lesson Content
   a. Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other.
   b. Earthquakes cause waves (vibrations) which have:
      i. a focus, the point below the surface where the quake begins
      ii. epicenter, the point on the surface above the focus.
   c. Energy released is measured in the Richter scale; each unit increase on the Richter scale represents a tenfold increase in energy released.
3. Skill Objective(s)
   a. Explain how stress forces affect rock and cause earthquakes.
   b. Describe the types of faults, how they form and where they occur.
   c. Describe how movement along faults changes earth's surface.
   d. Explain how the energy of an earthquake travels through the Earth.
   e. List and describe the types of seismic waves.
   f. Be able to name and identify the scales used to measure the strength of an earthquake.
   g. Explain how seismic waves are detected.
   h. Describe the procedure for finding an epicenter.
   i. Be able to correctly spell all vocabulary words.
   j. Be able to analyze and draw conclusions from a graph.

B. *Materials*
   1. Final test from Appendix Q (one copy for each student)
   2. Appendix R (one copy for the teacher)

C. *Key Vocabulary*
   None

D. *Procedures/Activities*
   1. Hand out final test (Appendix Q). Allow 30-40 minutes. Use Appendix R for key.
   2. Begin introducing your next unit with the remaining time in the period.

E. *Assessment/Evaluation*
   1. Final test which will assess their knowledge of the vocabulary, understanding of the causes and effects of earthquakes and ability to interpret data and draw conclusions.

VI. CULMINATING ACTIVITY

A. Final test (Appendix Q)

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Two-Column Notes
B. Appendix B: Worksheet on Vocabulary Words
C. Appendix C: Vocabulary Quiz
D. Appendix D: Chart on Types of Stress and Faults
E. Appendix E: Guide for Teacher During Playdough Activity
F. Appendix F: Guidelines for Teachers for Drawing on the Board
G. Appendix G: Key for Appendix B
H. Appendix H: Key for Appendix C
I. Appendix I: Key for Appendix D
J. Appendix J: Epicenter Lab
K. Appendix K: Key for Appendix J
L. Appendix L: See It, Say It, Got It Drawings
M. Appendix M: Study Guide for Final Test
N. Appendix N: Review Vocabulary Worksheet
O. Appendix O: Key for Appendix N
P. Appendix P: Key for Appendix M
Q. Appendix Q: Final Test
R. Appendix R: Key for Appendix Q

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TWO COLUMN NOTES ON EARTHQUAKES

earthquake	**- shaking and trembling of Earth** **- caused by stress on rock** **- rock breaks and shifts**
stress	**- force that acts on rock** **- changes its shape or volume** **- adds energy to rock and is released when it breaks**
three types of stress	**1. shearing** **- pushes horizontally in opposite directions** **2. tension** **- pulls on crust** **- middle gets thinner** **- occurs at diverging plates** **3. compression** **- pushes rock** **- folds or breaks** **- occurs at converging plates**

deformation - any change in shape or vol. of Earth's crust

fault
- breaks in Earth's crust
- caused by stress and movement

three types of faults

1. strike slip
   - caused by shearing
   - occur at transform boundaries
   - rocks move in opposite directions
2. normal
   - tension pulls apart
   - diverging boundaries
   - footwall goes up and hanging wall goes down
3. reverse
   - compression pushes
   - converging boundaries
   - hanging wall goes up and footwall goes down

friction	**- force that opposes motion of a surface as it moves across another surface**
types of land forms	**1. fault block mountains** **- caused by normal faults** **2. folds** **- bends in rock** **- caused by compression** **3. plateau** **- large area of flat land** **- elevated high above sea level** **- wider than tall** **- vertical faults push up a large, flat block of rock**
focus	**- point beneath surface** **- rock under stress breaks** **- earthquakes begin here**
epicenter	**- point on surface directly above focus**

seismic waves

- **vibrations traveling through earth**
- **start from focus**
- **carries energy when rock breaks**
- **energy greatest at epicenter**

three types of seismic waves

1. **P waves – primary wave**
   - **first to arrive at station**
   - **waves push and pull**
   - **fastest waves**
   - **travel through solids and liquids**
2. **S waves – secondary wave**
   - **come after P wave**
   - **waves move side to side**
   - **can't travel through liquids**
3. **L waves - surface waves**
   - **occur on surface**
   - **slowest waves**
   - **most damage**

seismograph

- **instrument that records and measures seismic waves**

magnitude	**- measurement of EQ's strength**
three types of scales	**1. Mercalli scale** **- measures effects** **- scale of I - XII** **2. Richter scale** **- rates size of waves** **- scale of 1 - 10** **- each unit represents a tenfold increase** **- 31 fold energy increase** **3. Moment Magnitude scale** **- measures total energy released**
locating the epicenter	**- take *difference* between arrival times of P and S waves** **- use graph to find distance** **- measure distance from city** **- draw circle** **- use three stations** **- intersection is epicenter**

Appendix B

Name _____

Directions: Using your vocabulary words, fill in the blanks with the most correct term that properly completes the sentence.

_____ is a force that acts on rock and often changes its shape or volume which means there has been a _____ on the rock. _____ stress occurs at transform boundaries and causes the rocks to move in opposite directions. If the rock is pulled and stretched it is called _____ stress. Sometimes the rocks are pushed together and the middle becomes thicker which is caused by _____ stress.

If the stress builds up and causes a break in the Earth's crust, a _____ forms. Often along a fault the _____ will cause the rocks to stick together building up a lot of stress which is released when a(n) _____ occurs. When shearing stress causes the rock to break it is called a _____ fault. _____ faults occur at divergent boundaries where there is tension. If the rock is being compressed at convergent boundaries a _____ fault could form.

When_____ faults uplift a block of rock, a _____ mountain forms. Sometimes compression bends the rock without breaking it and _____ appear.

Finally, if vertical faults cause a large, flat block of rock to be pushed up the result is a _____ .

Appendix C

Name _____

EARTHQUAKE VOCABULARY QUIZ

_____ 1. shearing	A. bends in rock
_____ 2. earthquake	B. force that acts on rock
_____ 3. fault	C. shaking and trembling of Earth
_____ 4. tension	D. stress that pushes on rock
_____ 5. normal fault	E. caused by tension stress
_____ 6. deformation	F. change in shape of Earth's crust
_____ 7. compression	G. breaks in Earth's crust
_____ 8. stress	H. caused by normal faults
_____ 9. strike-slip fault	I. force that opposes motion
_____10. friction	J. large area of flat land
_____11. fault block mountains	K. shearing forces occurring at transform boundaries
_____12. reverse fault	L. force that pushes horizontally in opposite directions
_____13. folds	M. caused by compression forces
_____14. plateaus	N. stress that pulls on crust

Appendix D

Name _____ Earthquakes: stress and faults

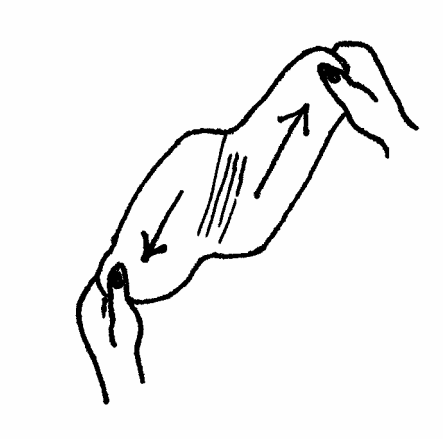
Directions: Complete the charts below with the appropriate information.

Type of stress	Causes	Effect
	A mass of rock is pushed in two opposite directions	Rocks break and slip apart
Compression		

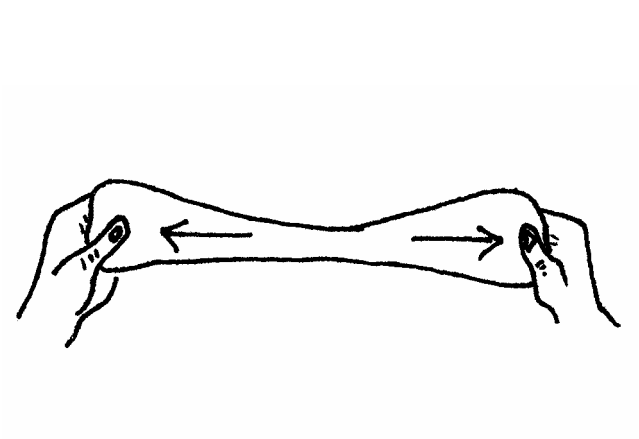
Type of fault	Cause	Effect
	shearing stress	
		footwall goes down and hanging wall goes up

Appendix E

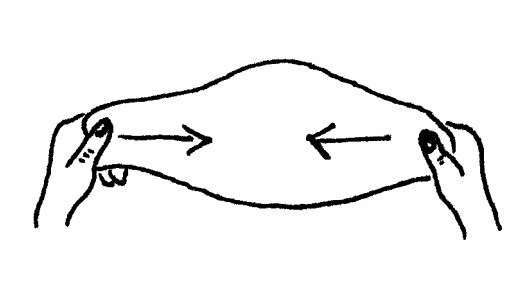
Guide for Teacher During Playdough Activity



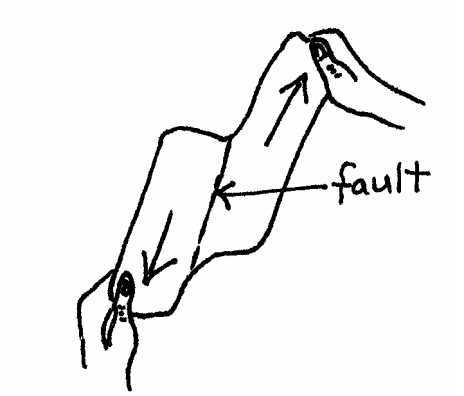
SHEARING STRESS



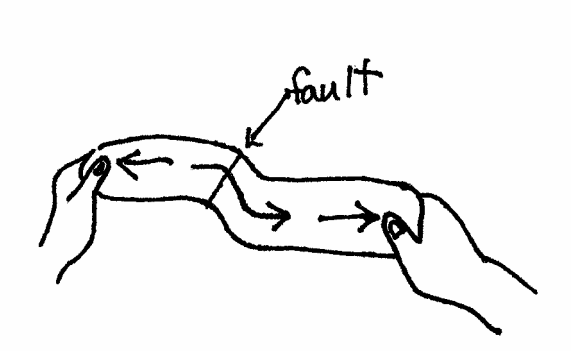
TENSION STRESS



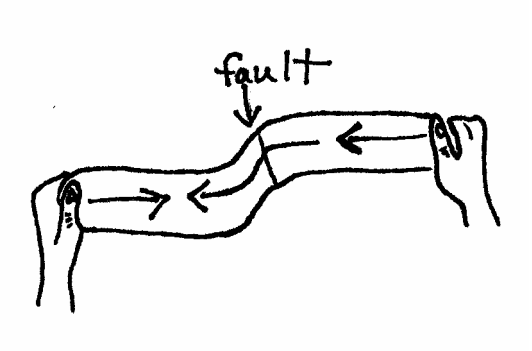
COMPRESSION STRESS



STRIKE-SLIP FAULT



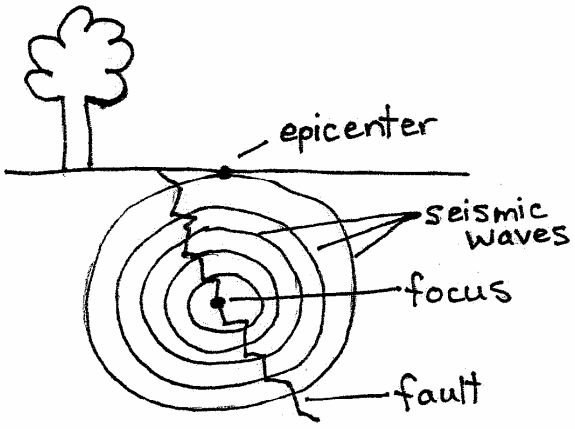
NORMAL FAULT

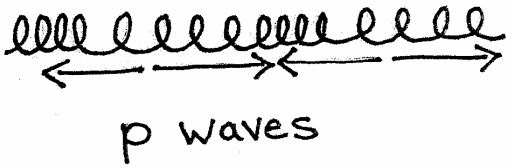


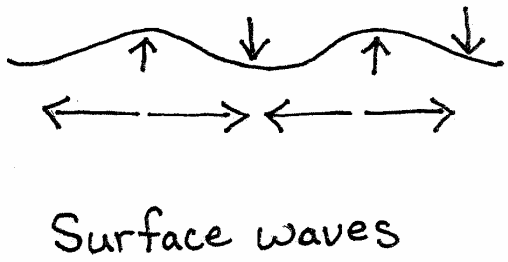
REVERSE FAULT

Appendix F

GUIDELINE FOR TEACHERS FOR DRAWINGS ON THE BOARD







Appendix G

Key for Appendix B

Name _____

Directions: Using your vocabulary words, fill in the blanks with the most correct term that properly completes the sentence.

___***STRESS***____ is a force that acts on rock and often changes its shape or volume which means there has been a _***DEFORMATION***_____ on the rock. ___***SHEARING*** stress occurs at transform boundaries and causes the rocks to move in opposite directions. If the rock is pulled and stretched it is called ____***TENSION***___ stress. Sometimes the rocks are pushed together and the middle becomes thicker which is caused by _____***COMPRESSION***_____ stress.

If the stress builds up and causes a break in the Earth's crust, a __***FAULT***____ forms. Often along a fault the ___***FRICTION***_____ will cause the rocks to stick together building up a lot of stress which is released when a(n) ___***EARTHQUAKE***____ occurs. When shearing stress causes the rock to break it is called a ____***STRIKE - SLIP***_____ fault.

____***NORMAL***_ faults occur at divergent boundaries where there is tension. If the rock is being compressed at convergent boundaries a _____***REVERSE***____ fault could form.

When __***NORMAL***_____ faults uplift a block of rock, a __***FAULT BLOCK***____ mountain forms. Sometimes compression bends the rock without breaking it and ___***FOLDS***____ appear.

Finally, if vertical faults cause a large, flat block of rock to be pushed up the result is a ___***PLATEAU***____ .

Appendix H

Key for Appendix C

EARTHQUAKE VOCABULARY QUIZ

L _____ 1. shearing	A. bends in rock
C _____ 2. earthquake	B. force that acts on rock
G _____ 3. fault	C. shaking and trembling of Earth
N _____ 4. tension	D. stress that pushes on rock
E _____ 5. normal fault	E. caused by tension stress
F _____ 6. deformation	F. change in shape of Earth's crust
D _____ 7. compression	G. breaks in Earth's crust
B _____ 8. stress	H. caused by normal faults
K _____ 9. strike-slip fault	I. force that opposes motion
I _____10. friction	J. large area of flat land
H _____11. fault block mountains	K. shearing forces occurring at transform boundaries
M _____12. reverse fault	L. force that pushes horizontally in opposite directions
A _____13. folds	M. caused by compression forces
J _____14. plateaus	N. stress that pulls on crust

Appendix I

Key for Appendix D

Directions: Complete the charts below with the appropriate information.

Type of stress	Causes	Effect
Shearing	a mass of rock is pushed in two opposite directions	rocks break and slip apart
Compression	pushes rock together	middle gets thicker folds are formed
Tension	pulls and stretches rock	middle gets thinner

Type of fault	Cause	Effect
Strike-slip	shearing stress	rocks slip past each other sideways
Reverse	compression stress	footwall goes down and hanging wall goes up
Normal	tension	hanging wall goes down and footwall goes up

LOCATING THE EPICENTER LAB

PROBLEM: How can you locate the epicenter of an earthquake?

HYPOTHESIS: _____

_____

_____

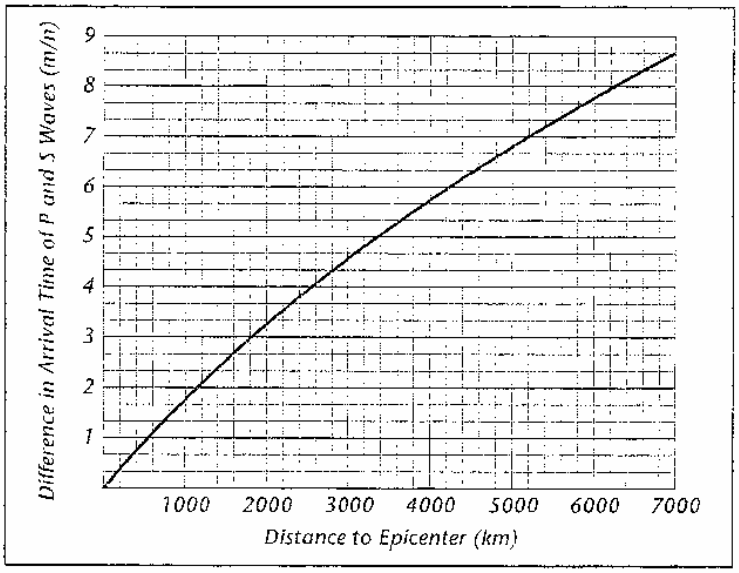
MATERIALS: drawing compass with pencil, graph with distance to epicenter, outline map of United States

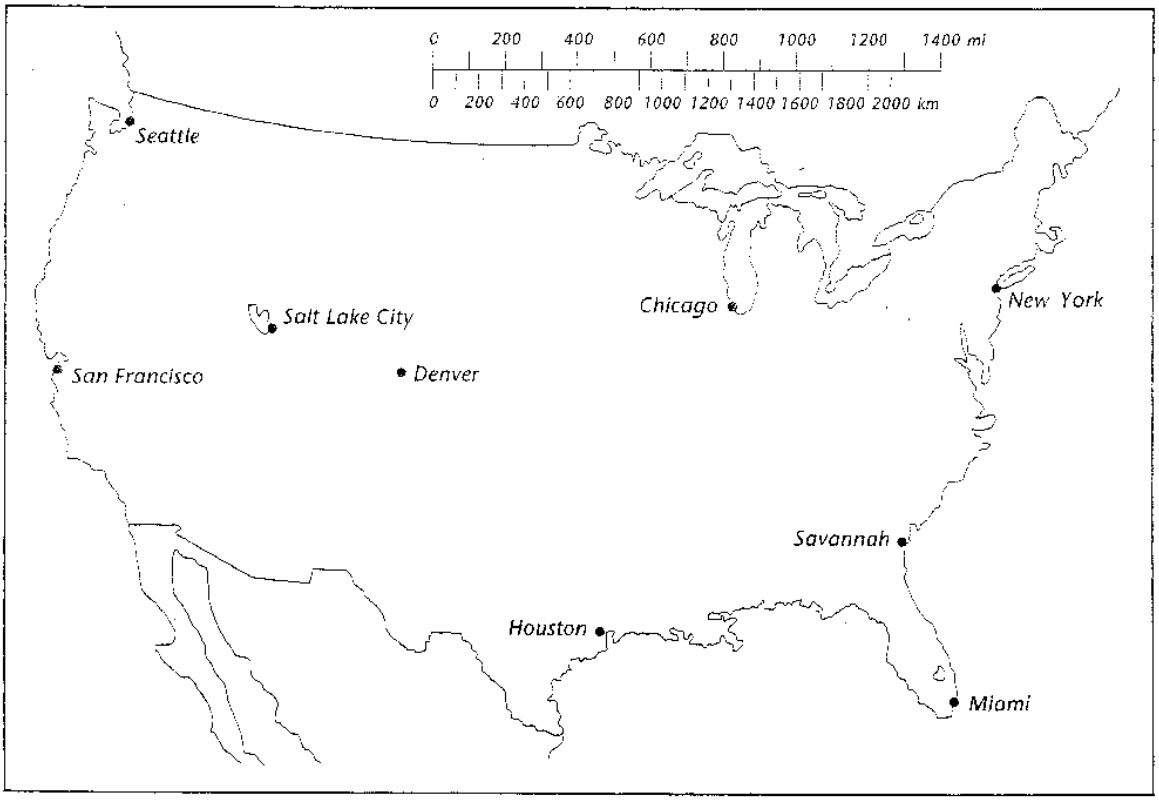
PROCEDURE:

1. The difference in arrival times between the P and S waves has already been calculated. Study the data table showing the difference in arrival times for the three seismographic stations.
2. Use the graph to locate the distance of the epicenter from the station with the information you have from the difference in arrival times. Find the difference in arrival time for Denver on the *y*-axis and Follow this line across to the point of intersection with the curved line. To find the distance to the epicenter, read down from this point to the *x*-axis of the graph. Enter this distance in the data table across from the city of Denver.
3. Repeat this step for Houston and Miami.
4. Set your compass at a radius equal to the distance from Denver to the epicenter.
5. Set the point of the compass on Denver and draw a circle using the radius from step four all the way around the city of Denver. Draw circles carefully. You may need to draw some of your circles off the map.
6. Repeat steps four and five for Houston and Miami.

DATA TABLE

CITY	Difference in P and S Wave Arrival Times	Distance to Epicenter
Denver, Colorado	2 min 10s	
Houston, Texas	3 min 55 s	
Miami, Florida	5 min 40 s	


Difference in Arrival Time of P and S Waves (m/s)
9
8
7
6
5
4
3
2
1
1000
2000
3000
4000
5000
6000
7000
Distance to Epicenter (km)


0 200 400 600 800 1000 1200 1400 mi
0 200 400 600 800 1000 1200 1400 1600 1800 2000 km
Seattle
Salt Lake City
Chicago
New York
San Francisco
Denver
Savannah
Houston
Miami

ANALYZE AND CONCLUDE:

Directions: Answer the following questions.

1. Observe the three circles you have drawn and locate the epicenter of the earthquake by finding the point of intersection of all three circles. Which city on the map is closest to the earthquake's epicenter? _____ How far, in kilometers is this city from the epicenter? _____

2. In which of the three cities would seismographs detect the earthquake first? _____ Which one would they detect last? _____

3. Where is the epicenter located? _____

4. About how far is the epicenter from San Francisco? _____ What would the difference in arrival times of the P and S waves be for a seismograph station in San Francisco? Use the graph to help you with this. _____

5. When trying to locate an epicenter, why is it necessary to know the distance from the epicenter for at least three seismograph stations?

_____
_____
_____
_____
_____

6. What happens to the arrival times between P and S waves as the distance from the earthquake increases? _____

7. Was your hypothesis correct? Explain in detail how your hypothesis compared with the actual procedure you just explored.

_____
_____
_____

Appendix K

Key for Appendix J

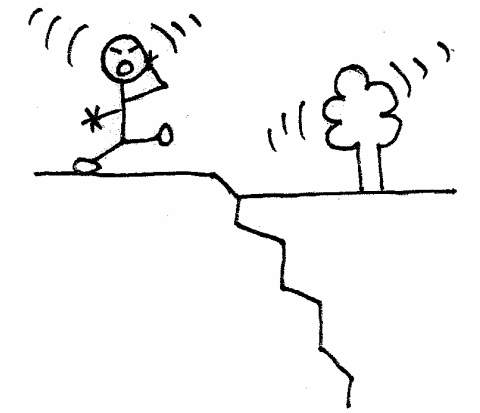
DATA TABLE:	Denver, Colorado	1200 km
	Houston, Texas	2600 km
	Miami, Florida	4000 km

ANALYZE AND CONCLUDE:

1. Seattle, 600 km
2. First = Denver; Second = Miami
3. The epicenter is located about 600 km southeast of Seattle.
4. 650 km from San Francisco; 1 min 20 s
5. Using three stations enables you to identify one epicenter location whereas using only two stations identifies two possible locations for the epicenter.
6. The difference in arrival times also increases.
7. Answers will vary. Make sure students compare their hypothesis to the actual procedure for finding an epicenter in their answers.

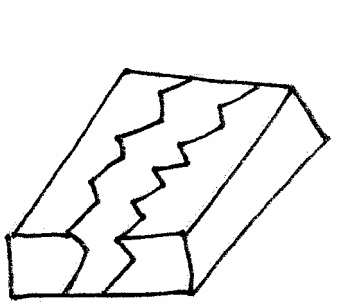
Appendix L

SEE IT, SAY IT, GOT IT DRAWINGS

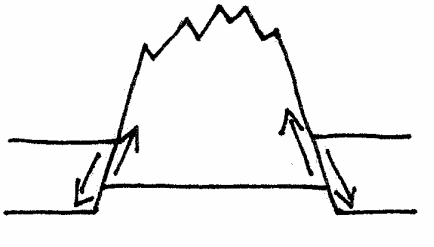


earthquake

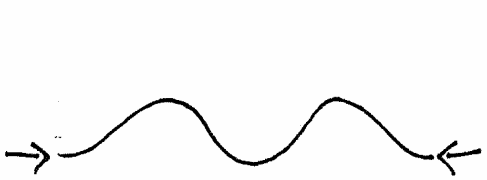
stress



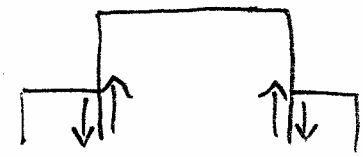
fault



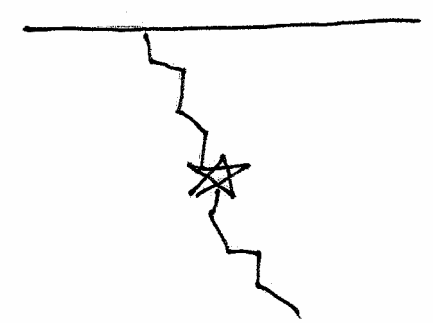
fault-block mountain



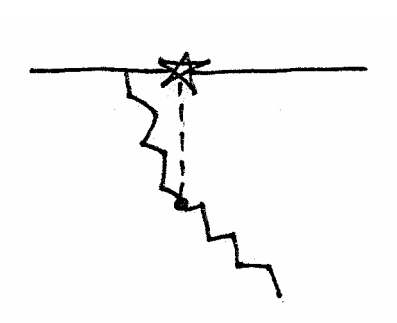
folds



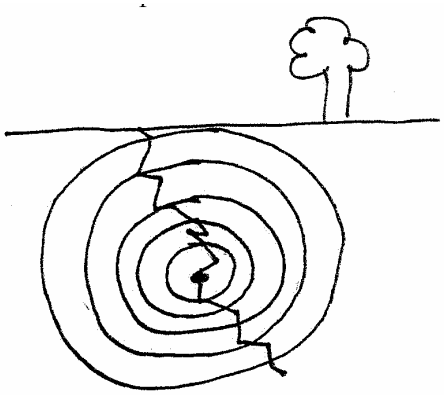
plateau



focus



epicenter



seismic waves

Appendix M

Study Guide for Earthquakes Unit

1. Explain how stress forces affect rock and cause earthquakes.

2. Describe the types of faults, how they form and where they occur.

3. Describe how movement along faults changes earth's surface.

4. Explain how the energy of an earthquake travels through the Earth.

5. List and describe the types of seismic waves.

6. Be able to name and identify the scales used to measure the strength of an earthquake.

7. Explain how seismic waves are detected.

8. Describe the procedure for finding an epicenter.

9. Be able to correctly spell all vocabulary words.

10. Be able to analyze and draw conclusions from a graph using the lab on locating the epicenter of an earthquake.

Appendix N

EARTHQUAKES PUZZLE

Directions: Locate the term in the magic square that matches the clue. Then write the number of the clue in the space. If all the numbers are correct you will solve the magic puzzle! When you add the numbers across, down or diagonally the sum will be the same. The four squares in each corner and the four squares in the center will also add up to the same answer.

fault _____	tension _____	strike-slip fault _____	focus _____
normal fault _____	Richter scale _____	primary waves _____	stress _____
secondary waves _____	surface waves _____	shearing _____	epicenter _____
reverse fault _____	deformation _____	seismograph _____	folds _____

1. a break in the Earth's crust where rock movement occurs
2. an instrument used to measure
3. any change in the shape or volume of the Earth's crust
4. the point in Earth where seismic waves originate
5. the point on Earth's surface directly above the focus
6. used to express strength of earthquake
7. compressional seismic waves
8. waves that can't move through liquids
9. a force that acts on rock that changes its shape
10. the most powerful shock waves
11. type of stress that pushes in opposite directions horizontally
12. type of fault where the footwall goes up and the hanging wall goes down
13. type of fault where the hanging wall goes up and the footwall goes down
14. rocks move in opposite horizontal directions
15. stress that pulls on crust
16. bends in rock caused by compression

Appendix O

Key for Appendix N
EARTHQUAKES PUZZLE

Directions: Locate the term in the magic square that matches the clue. Then write the number of the clue in the space. If all the numbers are correct you will solve the magic puzzle! When you add the numbers across, down or diagonally the sum will be the same. The four squares in each corner and the four squares in the center will also add up to the same answer.

fault **____1_____**	tension **_____15_____**	strike-slip fault **_____14_____**	focus **_____4_____**
normal fault **_____12_____**	Richter scale **_____6_____**	primary waves **_____7_____**	stress **_____9_____**
secondary waves **_____8_____**	surface waves **_____10_____**	shearing **_____11_____**	epicenter **_____5_____**
reverse fault **_____13_____**	deformation **_____3_____**	seismograph **_____2_____**	folds **_____16_____**

1. a break in the Earth's crust where rock movement occurs
2. an instrument used to measure earthquakes
3. any change in the shape or volume of the Earth's crust
4. the point in Earth where seismic waves originate
5. the point on Earth's surface directly above the focus
6. used to express strength of earthquake
7. compressional seismic waves
8. waves that can't move through liquids
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10. the most powerful shock waves
11. type of stress that pushes in opposite directions horizontally
12. type of fault where the footwall goes up and the hanging wall goes down
13. type of fault where the hanging wall goes up and the footwall goes down
14. rocks move in opposite horizontal directions
15. stress that pulls on crust
16. bends in rock caused by compression

Appendix P

Key for Study Guide Appendix M

1. Stress acts on rock to change its shape or volume. It adds energy to rock and is stored in the rock until the rock breaks. When it breaks the energy is released causing an earthquake. There are three types of stress: shearing, tension and compression (see Appendix A for definitions).

2. Faults usually occur along plate boundaries but can also occur in the interior. There are three types of faults: strike-slip, normal and reverse (see Appendix A for definitions).

3. The movement along faults can cause mountain building such as fault-block mountains, folds, and plateaus (see Appendix A for definitions).

4. The earthquake begins at the focus and seismic waves move out through the focus up to the epicenter.

5. The first waves out are the primary waves, then the secondary waves and finally the surface waves (see Appendix A for descriptions).

6. There are three scales used to measure earthquakes: Mercalli scale, Richter scale and the Moment Magnitude scale (see Appendix A for descriptions).

7. Seismographs are used to record the ground movements caused by seismic waves as they move through the Earth.

8. Take the difference between the arrival times of the P and the S waves. Take the difference between arrival times and use the graph to find the distance from the epicenter. Draw a circle around the seismograph station the data came from using the distance as the radius. Do this for at least three stations. The point of intersection is the epicenter.

9. See Appendix A for vocabulary words.

10. Practice using the graph from the lab (Appendix J) to ensure students understand how to find the distance to the epicenter.

Name _____

UNIT TEST ON EARTHQUAKES

Multiple Choice: Write the letter of the best answer for each question in the blank to the left.

_____ 1. Any change in the volume or shape of Earth's crust is called
a. deformation b. folding
c. faulting d. earthquake

_____ 2. Which type of seismic waves arrives at a seismograph first?
a. surface waves b. tsunamis
c. S waves d. P waves

_____ 3. Bends in rock caused by compressions forces can create landforms called
a. seismic waves b. folds
c. fault-block mountains d. plateaus

_____ 4. The point beneath Earth's surface where the crust breaks and triggers an earthquake is called the
a. epicenter b. fault
c. focus d. seismic wave

_____ 5. Which stress force pulls on and stretches rock?
a. shearing b. tension
c. normal d. compression

_____ 6. A break in the crust where slabs slip past each other is a(n)
a. fold b. epicenter
c. hanging wall d. fault

_____ 7. An instrument used to measure and record ground movements during an earthquake is called a(n)
a. seismograph b. Richter scale
c. magnitude d. Moment Magnitude scale

_____ 8. A type of fault that forms when the hanging wall goes up and the footwall goes down is called a(n)
a. tension fault b. normal fault
c. reverse fault d. strike-slip fault

_____ 9. Which type of waves is the slowest but creates the most damage?
a. P waves b. S waves
c. tsunami waves d. surface waves

_____ 10. Which scale measures the effects of an earthquake from I – XII?

a. Moment Magnitude
b. Mercalli
c. Richter
d. seismograph

Completion: Fill in the line to complete each sentence.

11. Compression, tension and shearing are three types of _____ that cause deformation of the crust.

12. A large area of flat land that is elevated high above sea level is known as a(n) _____ .

13. The _____ is a rating system that estimates the total energy released by an earthquake.

14. Surface waves begin at the point on the Earth's surface called the _____ .

15. _____ is the force that opposes the motion of one surface as it moves across another surface.

True or False: If the statement is true, write true on the line. If it is false, change the underlined word or words to make the statement true and write it on the line.

_____ 16. As the distance from the earthquakes increases, the difference in arrival times of the P and S waves <u>decreases</u>.

_____ 17. The type of stress that pushes masses of rock sideways in opposite directions is <u>tension</u>.

_____ 18. S waves arrive at a seismograph <u>after</u> P waves.

_____ 19. By drawing circles to show distances from three seismograph stations, geologists can locate the <u>magnitude</u> of an earthquake.

_____ 20. Fault-block mountains are produced by <u>normal</u> faults.

Essay: Answer the following question using complete sentences.

21. Explain in detail all the steps necessary in finding the epicenter of an earthquake.

_____
_____
_____
_____

LOCATION OF SEISMOGRAPH

CITY	Time for P Waves to Arrive	Time for S Waves to Arrive
Atlanta, Georgia	4 min, 50 s	8 min, 55 s
Detroit, Michigan	3 min, 25 s	6 min, 45 s
Portland, Oregon	2 min, 15 s	4 min, 50 s

22. What is the difference between P and S wave arrival times in each city?

    Atlanta _____

    Detroit _____

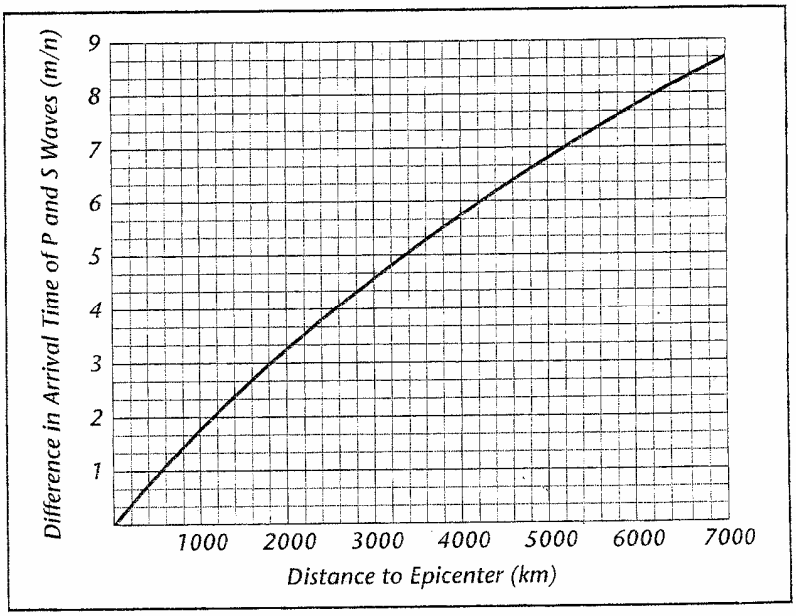
    Portland _____

23. What is each city's distance from the epicenter?

    Atlanta _____

    Detroit _____

    Portland _____



24. Do you now have enough information and materials to calculate the location of the epicenter? If so, what would you do next? If not, what do you need to finish the procedure?

_____
_____
_____
_____
_____

Appendix R

Key for Appendix Q

1. A
2. D
3. B
4. C
5. B
6. D
7. A
8. C
9. D
10. B
11. stress
12. plateau
13. moment magnitude scale
14. epicenter
15. friction
16. increases
17. shearing
18. true
19. epicenter
20. true
21. Find the difference between arrival times of the P and S waves. Calculate the distance from the epicenter by using a graph. Adjust the radius of a compass to match the distance found on the graph. Place the point of the compass on the city and draw a circle. Do this for at least three cities. The point of intersection of the three circles is the location of the epicenter.
22. Atlanta = 4 min 5 s
    Detroit = 3 min 20 s
    Portland = 2 min 35 s
23. Atlanta = 2600 km
    Detroit = 2050 km
    Portland = 1500 km
24. To be able to find the epicenter you would need a compass, a map and the graph, therefore the answer is No, they don't have enough materials to finish finding the epicenter.